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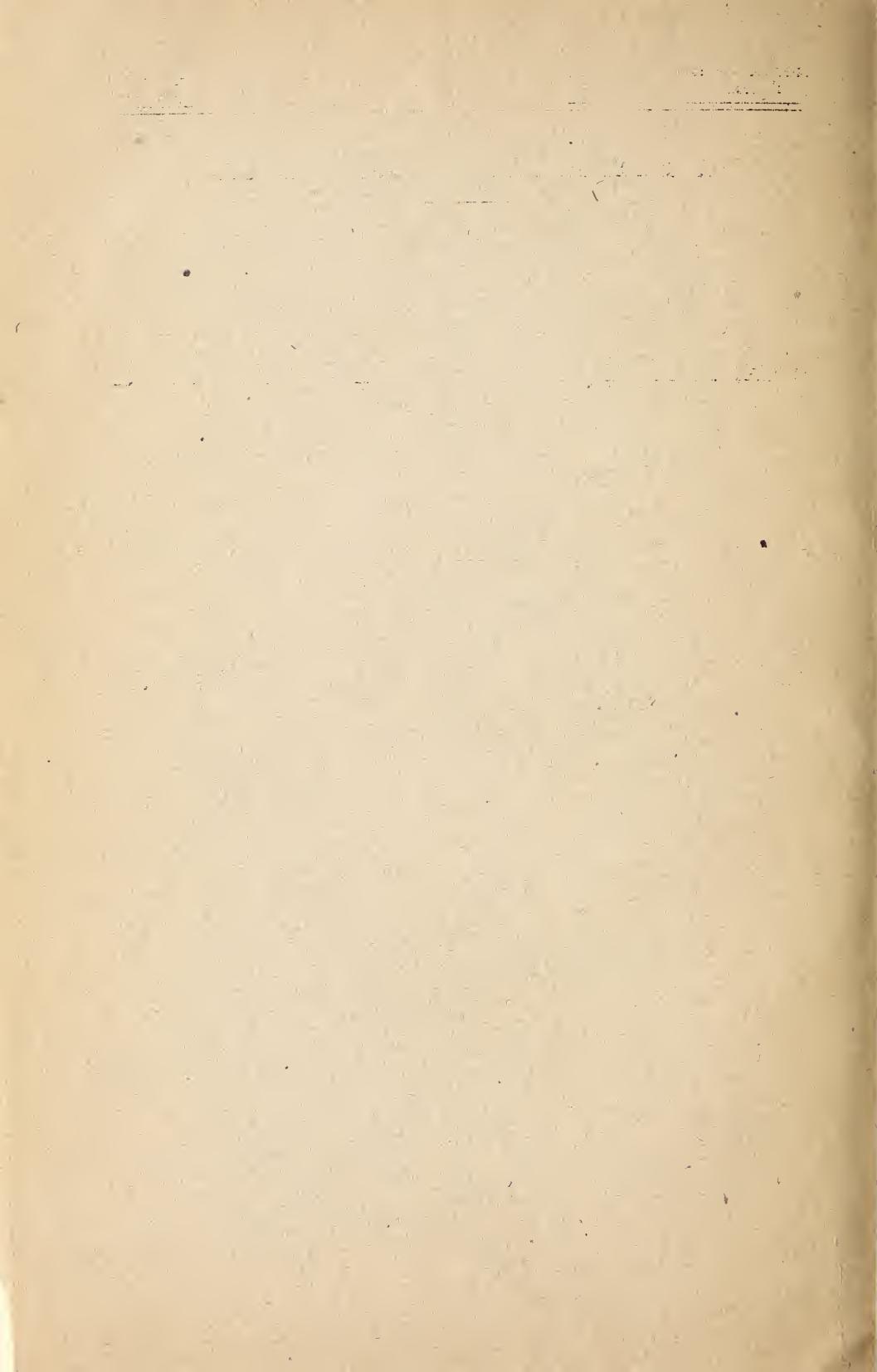
WORK AND EXPENDITURES OF THE
AGRICULTURAL EXPERIMENT STATIONS
1916

PART I OF REPORT ON EXPERIMENT STATIONS AND EXTENSION
WORK IN THE UNITED STATES 1916



WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

WITHDRAWN FOR EXCHANGE-A. M. L



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
STATES RELATIONS SERVICE,
Washington, D. C., July 16, 1917.

SIR: I have the honor to transmit herewith a report on the agricultural experiment stations in the United States for the fiscal year ended June 30, 1916, and on the work of the Department of Agriculture in relation thereto. This report has been prepared in accordance with the following provision of the act of Congress of March 4, 1915, entitled "An act making appropriations for the Department of Agriculture for the fiscal year ending June thirtieth, nineteen hundred and sixteen":

That hereafter there be prepared by the Department of Agriculture an annual report on the work and expenditures of the agricultural experiment stations established under the act of Congress of March second, eighteen hundred and eighty-seven (Twenty-fourth Statutes at Large, page four hundred and forty), on the work and expenditures of the Department of Agriculture in connection therewith, and on the cooperative agricultural extension work and expenditures of the Department of Agriculture and of agricultural colleges under the act of May eighth, nineteen hundred and fourteen, entitled "An act to provide for cooperative agricultural extension work between the agricultural colleges in the several States receiving the benefits of an act of Congress approved July second, eighteen hundred and sixty-two, and of acts supplementary thereto, and the United States Department of Agriculture"; and that there be printed annually eight thousand copies of said report, of which one thousand copies shall be for the use of the Senate, two thousand copies for the use of the House of Representatives, and five thousand copies for the use of the Department of Agriculture (38 Stat. L., p. 1110).

This report embodies all the information heretofore submitted in compliance with the provisions of 34 Stat. L., p. 64, sec. 5.

Very respectfully,

A. C. TRUE, *Director.*

Hon. D. F. HOUSTON,
Secretary of Agriculture.

STATES RELATIONS SERVICE.

A. C. TRUE, Director.

OFFICE OF EXPERIMENT STATIONS.

E. W. ALLEN, Chief.

RELATIONS WITH INSTITUTIONS FOR AGRICULTURAL RESEARCH.

Supervision of Work and Expenditures of the State Experiment Stations under Federal Appropriations.

E. W. ALLEN.
J. I. SCHULTE.
W. H. EVANS.
W. H. BEAL.

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 W. T. WHITE, B. S., Assistant, Fairbanks.
 H. S. LOYD, B. S., Animal husbandman, Kodiak.

Guam Experiment Station.

C. W. EDWARDS, B. S., Animal husbandman in charge, Island of Guam.
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 PETER NELSON, Assistant.

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 J. H. COWAN, Assistant in horticulture.
 R. A. GOFF, In charge of Glenwood Substation.

Porto Rico Experiment Station.

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 P. L. GILE, A. B., Chemist.
 C. F. KINMAN, B. S., Horticulturist.
 R. H. VAN ZWALUWENBURG, B. S., Entomologist.
 E. W. BRANDES,¹ M. S., Plant pathologist.
 T. B. MCCLELLAND, A. B., Assistant horticulturist.
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WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS, 1916.

By E. W. ALLEN, E. V. WILCOX, and J. I. SCHULTE.

RELATIONS OF THE OFFICE OF EXPERIMENT STATIONS WITH THE AGRICULTURAL EXPERIMENT STATIONS.

ADMINISTRATIVE AND ADVISORY RELATIONSHIPS.

The original text serving for the guidance of the Office of Experiment Stations in determining its relations with the agricultural experiment stations was phrased in broad terms in the Hatch Act in the authorization, "In general, to furnish such advice and assistance as will best promote the purpose of this act." The policies of the department with regard to the stations have been conceived in harmony with the obvious intent of the provision.

Later Congress extended the department's responsibilities by requiring that "the Secretary of Agriculture shall prescribe the form of the annual financial statement required under the above act [Hatch Act], ascertain whether the expenditures are in accordance with its provisions, and make report thereon to Congress." In accordance with this requirement, the office passes upon and approves the annual financial reports which are made by the experiment stations in accordance with prescribed schedules, considering these expenditures in direct relation to the nature of the work and the needs of the station, and on the basis of this and a favorable condition for the effective use of future allotments it authorizes the advance of funds to the stations by the Treasury Department. Under the Adams Act the supervision of work and expenditures goes somewhat further, for the department is charged with the administration of this law as a whole.

The Hatch Act, and still more specifically the Adams Act, are legislative avowals of the necessity for organized research as a basis for the further development of agriculture. Accordingly the Office of Experiment Stations has from the very beginning urged a liberal and constructive interpretation of these two great agricultural enactments upon the attention of the officials of the stations and colleges. Opportunity has been embraced to indicate in specific instances how

the work of the stations could be improved and strengthened, and how the most effective use of funds could be secured. In the early struggles of the stations, with lack of State funds, their needs were urgently called to the attention of State officials. Nearly every State has recognized its duty in this regard, with the result that the stations as a whole now receive larger appropriations from the States than from the Federal Government.

Furthermore, the Office of Experiment Stations has lent its aid and influence in improving the quality and raising the standard of agricultural research. It has aided in the search for qualified investigators. It has helped them in consulting the necessary literature. It has taken occasion to call attention to other work along the same lines. It has assisted in a constructive way in formulating projects and in providing competent methods of attack. By friendly, sympathetic but repeated suggestion the office has helped in bringing about a sharper division of labor between investigators, teachers, and extension workers. It has sought to encourage the provision of time, facilities, and liberty to the research worker in order that his energies might not be dissipated in a multiplicity of duties, but might be effectively and uninterruptedly centered on problems underlying the advancement of agricultural science.

These efforts have been exerted not only to prevent obstructions from falling in the path of agricultural progress, but to assist in making the Federal appropriations count to the fullest possible extent in furthering the wise and generous intent of the fathers of the Hatch and Adams Acts. The aim and the effort have been to stimulate and influence rather than to attempt to direct or supervise, and in the effort to aid in the development and attainment of proper standards and ideals, to take account of local conditions and needs rather than to shape all to a rigid type or common mold.

The adaptation of each station to its environment, "having due regard to the varying conditions and needs of the respective States and Territories," as prescribed by the Hatch Act, has been the guiding principle; and this is opposed to anything akin to standardization. But the qualities and requirements of research and experimentation are the same everywhere, and these determine the general character of the experiment station.

In the efforts of the office to conserve the Federal funds and make the work under them effectual and progressive, the stations have cordially met it halfway. It is a pleasure to be able to record the fact that relations with the stations have continued mutually cordial and sympathetic.

With the procession of years the stations have shown a great advance in effectiveness. The best investigators are now attracted to the stations by the opportunities offered there. The conditions for inves-

tigation have improved. They are now fully as good as at endowed universities. The standard of research has been raised. Station men now occupy a dignified place in the scientific world.

A DECADE UNDER THE ADAMS ACT.

The year 1916 was the tenth anniversary of the passage of the Adams Act, which has proved a vital force in the development of agricultural research. The period has been one of great activity and of advancement, which has affected all departments of the station work. It also has been marked by a more definite conception of the experiment station as primarily an institution for research.

The Adams Act passed Congress March 16, 1906. As it was decided the act itself did not carry an appropriation, it had to await an appropriation carried in the agricultural appropriation act, which came at the very end of the fiscal year, too late for much work to be started under it. For that reason only a part of the stations spent the first appropriation of \$5,000 to each State, more than one-fifth of the total appropriation being turned back into the United States Treasury.

The Adams Act was not merely supplementary to the Hatch Act to enable more of the same kind of activity; it was, as its language stated, an act to provide for investigation of a high and fundamental order, because progress under the Hatch Act had established the necessity for fundamental study and the activity had gone about as far as it could without additional funds.

Some one has said that the Adams Act has glorified research. It has emphasized it and has been the means of defining its essential qualities more definitely, perhaps, than has ever been done elsewhere in science. It was designed to enable researches and experiments which should be original and fundamental. The Hatch Act permitted such studies, and an important amount had been done under it, but it did not limit the activities of the stations to work of that grade or so closely and specifically aim at inquiry which should be original and searching, according to the accepted standards of scientific research. When the act passed it was characterized as being "the greatest opportunity for continued systematic research along agricultural lines which has ever been presented in any country," and time has borne out this estimate of it. It has been the greatest impetus to investigation, and it has transformed the American station from being a liberal borrower to being a large and important producer in agricultural science.

The Adams Act has had a far-reaching influence on all the work of the stations, regardless of the funds from which it is supported. The necessity of making the investigations thorough and exact in

order that they might be dependable and capable of scientific interpretation has resulted in more care in the preparation of the plans and in the matter of methods. The necessity of outlining the purpose and general plan of the inquiry at the outset has led to more careful preparation for an investigation and has led to the very general adoption of the project system in the experiment stations. At present there is a far more adequate realization of the limitations of some of the common methods of experimentation than formerly, and that they embody many modifying factors not measured or accounted for. There is a more critical examination of the sources of error in both observation and interpretation and a more guarded drawing of broad conclusions.

These changes in the nature of the work have had a marked influence on the professional requirements for station work. The qualifications are set higher and made far more exacting than formerly. It has come to be realized that the measure of efficiency of an experiment station is the sum of the efficiency of its workers, and that agricultural investigation requires training and preparation and special ability of a high order.

Another influence is seen in the larger opportunity for uninterrupted research and the provision of a station staff the members of which are to considerable extent relieved from any large amount of teaching duties or extension work. Improvement in this direction has come year by year. The extension work in particular has been found to require a force largely its own, and this has had the effect of relieving the station men from arduous duties in that connection.

There also has been progress in the organization of station work. It is being developed more largely out of a constructive purpose and in accordance with a definite plan. It is recognized that no station can cover the entire field of agriculture or all the important questions at any one time, and hence that a selection must be made based to considerable extent on the special requirements of the State. Further than this, the necessity for continuity has been impressed as a result of the more fundamental undertakings. These usually require to be continued for a period of years, and they can not be interrupted or laid aside for something else without very material disadvantage.

The inspection work has become a much less conspicuous feature at the stations, and has been so organized as to avoid interference with investigation and experiment. Facilities for publishing the technical and research activities of the stations have materially increased in the decade. A considerable number of stations have established research series of bulletins, or otherwise differentiated their technical publications from the regular bulletins intended for the general public. The publication of scientific papers in current journals of this country and Europe has become very common, where formerly

it was exceptional, and has thus brought the name of the stations into close association with other agencies for investigation. The *Journal of Agricultural Research* has been established by the Department of Agriculture and furnishes a special medium for station contributions.

But this enlarged research activity has in no way affected the ultimate purpose of the stations or their definite application to the vital practical problems of the agricultural industry. Through the extension divisions the stations maintain a more direct contact with agricultural practice than ever before, and because they furnish the stock in trade for the extension teaching it is evident that they must make their work more searching and enlightening—not only in practical results but in the understanding of them. The field has grown to seem much larger and the task much deeper than at first. Perhaps one of the greatest truths which has been emphasized is the fact that the task must not only be continuous but is almost endless—that the stations can not hope to touch bottom in all there is to know about the simplest subjects with which their investigation concerns itself.

Ten years under the Adams Act has given new ideals and new standards, more exacting requirements as regards methods and workers, and a vastly increased product in the form of results which are of more permanent character and more logically understood and applied. It has been a highly profitable era.

COORDINATION OF STATION WORK.

This subject has received considerable attention of late, and some progress has been made in the direction of voluntary cooperation or shaping of work in accordance with what is going on elsewhere. But there is still opportunity for closer relations and conformity in considerable of the experimental work.

At the first annual convention of the Association of American Agricultural Colleges and Experiment Stations in 1887 Dr. W. O. Atwater read a paper on Coordination of Work in Experimentation. Dr. Atwater suggested the desirability of ascertaining "in what ways the different stations may advantageously avoid repeating work which has been done, or is to be done, by other stations, or may cooperate in the study of problems of common interest." A committee reporting on that subject wisely expressed the view that "freedom of action is one of the first conditions," but suggested, nevertheless, that as the work developed there would be ways in which stations could advantageously unite in the study of specific questions. "Stations that are to work in dairying may well consult together and seek counsel of specialists in their selection of questions and the methods for their study. The same will apply to those who are interested in experiments in feeding, fertilizing, and so on, through

the list of the more general subjects of inquiry." The committee specified two directions in which cooperation might be attempted immediately or very soon and with promise of success, namely, the unifying of fertilizer inspection and the carrying on of field experiments with fertilizers.

In general, the committee felt that "the most effective and useful coordination and cooperation will come from mutual consultation," and from this it looked to much advantage as the work developed.

At the annual convention in 1889 the matter of coordination of station work was thoroughly discussed, and a committee appointed to consider the question made the following report: "Whenever a group of States having any one interest in common can study together through their experiment stations any one important problem by voluntary communication with each other or by an organization of said group of States, then it is recommended and urged that co-operative work be done so far as it is feasible."

The movement foreshadowed by the committee reports at once began to take definite form. Perhaps the first grouping of experiment stations for cooperative action was concerned with fertilizer inspection. The New England, New York State, and New Jersey stations began to hold annual conferences for standardizing the values to be assigned to fertilizer ingredients and the methods of fertilizer control. These annual conferences offered opportunity for discussion of other questions of mutual interest. Their scope was, therefore, gradually broadened, until at present any urgent problem requiring concerted action may be considered in conference and plans adopted for attacking it. One of the recent problems under discussion was white-pine blister rust. Tacit understanding may also be reached as to a division of large questions, or provision which will result in the studies of different stations supplementing each other.

For two years the southern stations (Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, Kentucky, Tennessee), working through the Southern Agricultural Workers' Association, have had under consideration plans for the general coordination of their work in agronomy and animal husbandry, with committees representing each of these subjects. Both of these committees presented detailed reports at the meeting of the association in January, 1917. The agronomy committee found 170 agronomic projects in operation at the various southern stations. It reported that "many stations are working on identical or similar projects, and that in many cases each station is doing its own work without reference to what is being done by the other southern stations having similar soils and climatic conditions." The committee cited 35 instances in which two or more stations are conducting identical projects or lines of work, apparently without reference to

one another or to other stations who are working at the same problems.

As a result of their study of the possibility of coordinating station work, this committee recommended "(1) that in agronomy work this association recognize eight main soil provinces * * * and that this classification be used as largely as possible as the basis in adjusting the agronomy work of the Southern States; (2) that as nearly as practicable in starting new work in any of the Southern States an understanding be had with all the workers through correspondence or by conference before the work is started, so that the investigations being conducted in the several States on the same character of soils shall be planned so that there will be eliminated, as far as possible, all unnecessary duplication; * * * (3) that work in force at the present time in each of the Southern States shall be so adjusted in conference, or otherwise, as to eliminate, as far as possible, all unnecessary duplication; * * * (4) that all stations, in starting new work in plant production experiments, are requested to record and report when publication is made of the results of the following data: Location of the experiments, time covered by the experiments, type of soil, extent of the type in the State, etc.; * * * and (5) that a permanent committee of this association on agronomy work for the South be appointed, or else the States Relations Service be requested to designate a man in that office to be in a position at all times to supply the heads of agronomy divisions of the Southern States with specific information with reference to agronomy work being conducted by the southern stations. It is believed that such information, disseminated among agronomy workers of the South, will tend to greater unification of work and to better adjustment of the same throughout the southern territory."

Similarly, the committee on live-stock experiments brought together a list of the projects in that line now in progress in the several southern experiment stations, and pointed out for illustration numerous cases of duplication of work, notably on cottonseed toxicity, effect of different feeds on swine, and effect of winter feeding of steers on summer gains while on pasturage. The committee strongly urged a much larger measure of coordination in the animal-husbandry work, believing this to be necessary in order to place the experimental work in the South on a higher and more permanent basis.

"There are many practices and conditions which have grown up with the work that should be eliminated and substituted with broader and more fundamental problems and far-reaching ideas. The improvement that is undertaken should not consist of details which each man in the States knows best, but rather those broader and more

fundamental problems which cover the South as a whole. The only practical way of solving these problems, it seems apparent to the committee working on this matter, is to establish permanent cooperation whereby the different workers may develop their work under congenial and effective relations."

Among its specific recommendations the committee suggested the annual publication of complete lists of the projects under way at each of the stations, together with a statement regarding the progress made on each of these, mentioning work in contemplation as far as possible. It suggested that the cooperation of this office be secured in the filing of all projects in progress or contemplated, so that these might be available to workers planning new experiments or experimental enterprises.

Finally, the committee urged that "plans for scientific research work should be carefully worked out and executed. More work of this nature should be inaugurated, thus covering the field with broader and more fundamental problems of value and interest to the South as a whole. Standard methods and apparatus for performing this work should be adopted so comparisons will be directly applicable to a universal standard. Progress of the experiments should be reported through some recognized scientific medium."

There are also many instances of cooperative plans now in operation among the stations. These plans vary greatly in scope and formality. They may involve the whole work and policy of the co-operating stations, or, at the other extreme, they may be concerned merely with a limited specific problem involving a single worker at each station. Again, these cooperative arrangements may be of the most informal nature, mere verbal agreements among station workers in the same field, or they may be based on formal written contracts approved by the directors of the cooperating stations.

As illustrations of the cooperative coordination of work among the stations the following instances may be mentioned. The North Carolina and Mississippi stations are cooperating in a study of place effect on cotton. The New York Cornell and Missouri stations are making a joint study of the influence of environment in producing variation in wheat. The New York State and Illinois stations are cooperatively investigating problems of milk sanitation. At present the problem is to determine the sources of the bacterial contamination of milk. The New York State station gives its attention to the cow and stable and the Illinois station to milk utensils. The Colorado and Montana stations are cooperating quite informally in a study of niter spots in soils. Avian tuberculosis is under joint investigation by the North Dakota and Oregon stations. The Wisconsin, Iowa, and Delaware stations have joined in a study of the immunity of cabbage

varieties to yellows or wilt. The New Hampshire station has a cooperative agreement with the Carnegie Institution in a project on sheep breeding. The Connecticut State station has joint projects with Harvard University in corn, tobacco, and tomato breeding, and with Yale University in researches on the nutritive value of proteins. The Illinois station also maintains advisory relations with Yale University in studying the food value of different proteins. The West Virginia station and Chicago University cooperatively employ the services of a specialist in a study of the physiological effect of pruning. The botanists of the Washington, Oregon, Idaho, Montana, and Colorado stations have formed an organization for the coordination of their work.

Perhaps the most intimate scheme of coordination is that which has been put into effect between the Idaho and Washington stations. The scheme involves a cordial cooperation and understanding relative to work and publications to avoid unnecessary duplication. Bulletin manuscripts prepared by either station are submitted before publication to the other station in order that it may determine whether it wishes to order copies for distribution in its State when the subject matter is of mutual interest. The phases of the apple-rosette problem have been divided between the botanical department of one station and the horticultural department of the other station. Since one of the two stations is well advanced in the investigation of wheat smut, the other station has voluntarily agreed to keep out of that field. The details of further cooperation are to be settled by conferences between the two stations. The plan is operating well.

These instances of mutual coordination of station work are by no means exhaustive. They indicate quite clearly, however, the varied possibilities of concerted action or adjustment among the stations. The number of stations concerned in these cooperative efforts ranges from two to eight. Moreover, as above indicated, the stations are joining hands with universities and other institutions in the prosecution of their research work. Again, nearly every experiment station has cooperative arrangements with this department concerning one or more projects. The form which these mutual agreements have taken has been determined by the needs and conditions of each particular occasion.

Obviously no single set of rules could be recommended for all cases. But, on the contrary, the actual instances of concerted effort among the stations bear testimony to the wisdom of the committee which suggested at the first annual convention of the station "that the most effective and useful coordination and cooperation will come from mutual consultation."

THE STATIONS AND REGULATORY WORK.

The committee on experiment station organization and policy presented a report at the meeting of the Association of American Agricultural Colleges and Experiment Stations in the summer of 1915, which dealt with the matter of inspection work and regulatory activity. It was pointed out that regulatory functions came to the stations quite early in their history, some of the stations indeed having their origin in control work. These institutions had shown the necessity for such inspection, and as they were frequently the only agencies for the purpose, the work was naturally assigned to them. Gradually a great variety of regulatory and promotion work developed, including the inspection of fertilizers, feeding stuffs, nurseries, fungicides and insecticides, human foods, dairy apparatus, seeds, paints, foul brood, animal diseases, etc. In addition, the stations were expected to participate actively in the campaign for freeing territory from the cattle tick and other animal diseases, prepare medicines or preventives for live stock, serum, virus, etc., conduct tests for advanced registration of dairy stock, supervise laws for stallion registration, and many other things.

The stations have, in large measure, worked out the methods and the means for conducting these activities in an effective, just, and reliable way. From the nature of their organization they have proved an ideal public service—competent, reliable, free from contamination, and largely beyond political influence. But since the methods have been so fully worked out, systematized, and standards set for them, it was pointed out that the execution of these regulatory functions has become largely a matter of routine and there is no longer the same need for association with the stations that there once was. In most States there are other agencies which can take over these functions, and there are plenty of trained persons competent to perform the routine duties. While the inspection work was formerly quite a source of revenue, it has become relatively small, amounting in 1915 to about \$343,000 out of a total of more than \$5,000,000. It carries with it a considerable amount of interruption, distraction, and administrative attention.

The report held that logically the regulatory work is "just as much a part of the State governmental machinery as the enforcement of other laws and measures. The States should prepare to take care of it, and in many cases they are now in far better condition to do this than formerly. The retention of such measures by the agricultural colleges is retarding the formation of strong State departments of agriculture, which it is in the interest of the colleges to promote. * * *

"The assignment of regulatory functions to an educational institution is to be justified only on the grounds of temporary expediency. It diverts attention from the real work and purpose of the institution, and it often places the institution in a wrong attitude before the people. It is a confusion of government and education."

Movements in the direction of a transfer of the inspection and other regulatory work are in progress in several of the States. The advisability of such a transfer is now more widely recognized. It is felt by many that the time has come when it might be made without weakening the efficiency of the service or the relations of the stations with the farmers. The latter relations are no longer dependent on this type of service.

FUNDS AND EQUIPMENT.

The total revenue of the experiment stations, including the insular stations, for the fiscal year ended June 30, 1916, amounted to \$5,334,073.93, the increase over the revenues of the preceding year being \$47,691.40. This total was made up of \$1,559,978.34 received from Federal appropriations, \$2,303,824.19 from State and Territorial allowances, and \$1,490,272.40 from fees, contributions, sales of products, and other sources of income. Of the total financial support of the stations for the year about 29 per cent came from the Federal appropriations and approximately 43 per cent from State and Territorial funds. As compared with the year before, the amount of the Federal funds available to the stations remained practically the same, while the State and Territorial funds were greater by \$174,220.15. The receipts from fees, sales, and other miscellaneous sources were smaller by \$106,506.09 than those of the preceding year, and the value of the additions to station equipment was also less, but still totaled over a million dollars.

The State support of the stations was maintained in increasing measure and the number of stations receiving no financial assistance from the State during the past year was reduced to six. In many States the station work, as a result of State aid, has developed along-different important lines and has consequently covered the field of experimental research in a more satisfactory manner. A greater and better coordination of the various phases of agricultural work is brought about by adequate funds, and these in the end are often expended more economically. To call attention to instances of liberal State support it may be mentioned that the total station revenues for the fiscal year 1916 amounted to \$387,386.49 in Indiana, \$360,071.19 in Ohio, \$282,303.47 in Illinois, \$275,305.48 in Minnesota, \$263,803.82 in Kentucky, \$203,404.08 in California, \$191,853.33 in Texas, and \$176,045.84 in Iowa. In the States enumerated the State

appropriations ranged from \$282,543 in Ohio to \$71,129.79 in Kentucky. Among other important State appropriations to the stations, together with increases in lands, buildings, and other equipment, the following are worthy of note:

The Alabama station was allotted \$25,000 by the State for a serum plant, with an additional sum of \$3,000 annually for its maintenance.

New buildings erected the past year by the Arizona station included a curing house at the Tempe date orchard and silos at the Prescott and Cochise dry farms. Offices of the director and of the various station departments in the newly completed agricultural building were occupied during the year.

The University of California set aside an appropriation of \$350,000 for a building to be known as Hilgard Hall and which is to be the headquarters of seven station and college of agriculture divisions. A sum of \$25,000 was allotted for the equipment of the building. The Citrus substation at Riverside has entered upon its newly acquired tract, and the erection of buildings under an appropriation of \$125,000 for the purpose was planned.

The construction of a central heating plant under a State appropriation of \$50,000 was begun by the Colorado college and station.

The Delaware college and station began the construction of an agricultural building to cost about \$280,000, part of which will be used by the station.

The Florida legislature aided the station with an appropriation of \$2,500 for general expenses, \$2,000 for repairs, and \$2,750 for printing, and made an appropriation of \$16,500 for the ensuing biennium, including \$5,000 for maintenance, \$4,000 for repairs and fixtures, and \$7,500 for printing.

The Georgia legislature appropriated \$2,500 for enlarging laboratory space, maintaining buildings and grounds, and extending the station work to different parts of the State.

Of a State appropriation of \$195,500, the Illinois station devoted \$114,000 to investigations in agronomy. A genetics building erected during the year provides offices and laboratory facilities for extensive breeding experiments with small animals.

The Iowa station completed a hog house at a cost of \$1,000 and a horse barn on the dairy farm at a cost of \$5,000, together with several minor structures. Provision was made for the construction of a dairy barn to cost \$18,000, and the animal-husbandry section completed plans for a general laboratory building.

The Kansas station, in addition to a State appropriation of \$40,000 for general purposes and \$37,000 for conducting the substations, was allowed \$3,000 for a refrigeration plant and \$1,000 for a poultry laboratory.

The Kentucky station established a department of animal pathology at the beginning of the year and erected a live-stock barn and tile silo.

The Maryland station received a State appropriation of \$5,000 for soil work. A bill passed by the legislature toward the close of the year provides an appropriation for the station of \$25,000 per annum for the ensuing biennium, as well as \$5,000 per annum for the work at the Ridgley substation.

The legislature of Massachusetts appropriated \$8,000 for the establishment of a market garden substation which it is planned to locate in the trucking section around Boston. An appropriation was also made for tobacco investigations.

The Minnesota station completed a research laboratory in animal pathology and constructed an additional greenhouse at the fruit farm. While there was some reduction in the sum available for the maintenance of this station the past year, the maintenance appropriations for the five substations and for the fruit-breeding farm at Zumbro were increased from \$83,900 to \$105,900.

The Missouri station made material additions to and improvements in its research laboratory equipment, including a refrigeration plant installed in connection with its animal nutrition work.

At the Nebraska station a dairy building, costing with modern equipment about \$193,000, was nearly completed during the year. In addition to student and research laboratories, reading rooms, lecture and classrooms, and offices, the building contains a modern refrigerating plant, which provides cold storage facilities for work in dairying and also in horticulture, home economics, and veterinary science.

The Nevada station built a serum laboratory at a cost of \$1,500.

The New Jersey stations constructed a greenhouse laboratory for the department of botany at a cost of \$3,500, and further enlarged their equipment by the purchase of 35 acres of land for experimental work in pomology and vegetable gardening. A special appropriation of \$2,000 was made for the purchase of specimen types of live stock.

The New Mexico Legislature appropriated \$5,000 for the use of the station, this first appropriation for maintenance becoming available in December, 1915.

The New York Legislature appropriated \$100,000 for an administration building at the State station at Geneva.

The North Carolina station erected additional buildings to the value of \$2,500 in connection with poultry and tobacco investigations.

The North Dakota station received from the State \$25,000 for general work, \$3,500 for creamery apparatus and equipment, \$3,000 for the maintenance of the serum institute, \$25,000 for the maintenance of five substations, and \$5,000 for special live-stock work.

The State appropriations to the Ohio station included \$180,780 for salaries and labor and \$91,763.20 for maintenance.

The Oregon college and station occupied during the year a new forestry building, erected at a cost of about \$40,000. The building provides offices, classrooms, and laboratories, including a large laboratory for logging engineering, and several smaller ones for studies of the manufacture of wood products.

The South Dakota station received from the State \$1,000 for printing popular bulletins and \$1,500 for work with alfalfa. About \$18,000 was received for the maintenance of the substations.

During the year additional buildings at the various substations in Texas, including a model barn at Denton, were erected and land was purchased for a goat substation for which the legislature allowed \$10,000 for the biennium to supplement private funds for the purpose. A barn for the department of agronomy was erected on the station farm. The legislature granted \$140,582.50 for the first year and \$135,000 for the second year of the biennium for the main station and the substations. It is planned to erect a station building to cost \$100,000 with feed-control funds.

The Washington station constructed an insectary during the year and acquired 10 acres additional land for experimental work by the department of botany.

The West Virginia station received a State appropriation of \$20,000 for experiment station work, established a department of forestry, and acquired several hundred acres additional land for experimental work in poultry, dairy, and animal husbandry, horticulture, agronomy, and soils. The State appropriated \$100,000 for a new agricultural building for which the plans were prepared. A series of four greenhouses was about completed during the year.

The Wisconsin station received from the State \$10,000 for publications. An addition was made to the hog-cholera serum plant and a cement silo was erected for use in feeding experiments. A new barn designed for experimental breeding work was occupied during the year. The substations received \$18,500 in addition to \$3,500 for construction. With this last appropriation buildings were put up at Ashland Junction, Marshfield, and Spooner.

The Wyoming station fitted up a special laboratory for research work with cements and secured funds for the better equipment of the laboratory devoted to general research work in chemistry. An appropriation of \$3,000 for work on alkali soils and for breeding

stock, together with \$1,000 for laboratory equipment, was received from the State.

The following journals of interest to the stations have recently been established:

Genetics, a periodical record of investigations bearing on heredity and variation, issued bimonthly, made its appearance during the year, the first number appearing in January, 1916. The editorial board of this new journal includes a number of experiment station men prominent in this particular field of work and the journal forms an excellent medium for the publication of much of the scientific material secured at the stations.

Soil Science, a monthly journal devoted mainly to soil physics, soil chemistry, and soil biology, also made its appearance in January, 1916. This journal is under the control of station men and its consulting staff of editors includes station workers and other scientists in this country and abroad. The journal offers a means of publication of the more technical matter of the soil research work of the stations, and the many contributions of this character which it presents indicate at once that the stations are ready to avail themselves of the opportunity of publication, and that the journal fills a recognized need.

The first number of the Journal of the Association of Official Agricultural Chemists was distributed in May, 1915. This journal appears quarterly and contains among other matters the reports of investigations of value to food, drug, and feed control chemists. Its relation and importance to station work and workers needs no comment.

PERSONNEL.

The changes which occurred in the personnel of the stations during the year present no new features to occasion comment. The personal equation as usual was a large factor in the changes. Larger opportunities and better salaries were in most cases the chief inducements. Changes in the directorship occurred at a number of stations. E. D. Ball, director of the Utah station, was succeeded by F. S. Harris; E. D. Sanderson, of the West Virginia station, by J. L. Coulter; B. T. Galloway, of Cornell, by A. R. Mann; and W. J. Schoene, of the Virginia station, by A. W. Drinkard, jr. R. H. Forbes, of the Arizona station, and H. G. Knight, of the Wyoming station, were on leave of absence for special studies. P. H. Rolfs, director of the Florida station, was made also dean of the college of agriculture. At two stations the work of the director's office was strengthened by the appointment of an assistant director—F. B. Morrison in Wisconsin and R. W. Thatcher in Minnesota.

A few changes also occurred in the presidency of agricultural colleges with which stations are connected. J. L. Snyder, of Michigan, was succeeded by F. S. Kedzie; J. H. Worst, of North Dakota, by E. F. Ladd; J. A. Widtsoe, of Utah, by E. G. Peterson; and E. A. Bryan, of Washington, by E. O. Holland. E. C. Elliott was appointed chancellor of the University of Montana, comprising the State university, State agricultural college and experiment station, school of mines, and State normal school. J. W. Cantwell was appointed president of the Oklahoma College of Agriculture.

Among other more important changes in the station staffs the following may be mentioned: W. J. Robbins was appointed plant pathologist at the Alabama station to succeed F. A. Wolf, who went to the North Carolina station. J. F. Nicholson was made agronomist at the Arizona station and W. W. Burr became agronomist at the Nebraska station. J. B. Rather became chemist of the Arkansas station, W. C. Etheridge was appointed agronomist in Florida, and E. P. Humbert left the New Mexico station to become cotton breeder at the Texas station. W. T. McGeorge, chemist of the Hawaii station, was succeeded by M. O. Johnson.

C. E. Fleming was made head of the new department of range management at the Nevada station, J. B. Davidson, of Iowa, became professor of agricultural engineering in California, W. G. Shaw succeeded M. Jacob as veterinarian at the Tennessee station, H. K. Gayle was appointed animal husbandman in Mississippi, L. A. Higley succeeded R. F. Hare as chemist and F. C. Werkenthin succeeded J. M. Mann as botanist at the New Mexico station. At the Texas station F. B. Paddock was promoted to be entomologist in place of Wilmon Newel.

In Washington J. W. Kalkus succeeded as station veterinarian S. B. Nelson, who will give his time to college work. A. G. McCall of the Ohio State University came to the Maryland station as agronomist. W. McFarlane was appointed in charge of the soil division in Oklahoma, H. P. Barrs succeeded H. S. Jackson as botanist and plant pathologist in Oregon, J. J. Taubenhaus of the Delaware station was appointed plant pathologist in Texas, and H. F. Wilson, of Oregon, succeeded J. G. Sanders as entomologist at the Wisconsin station.

Two pioneers in the field of agricultural education and research, Dr. Eugene W. Hilgard of the University of California and Dr. Thomas J. Burrill of the University of Illinois, were called by death during the year. Brief sketches of their lives and work are given below.

The death of Dr. E. W. Hilgard on January 8, 1916, closed a notable career in the service of agricultural education and research, begun in the pioneer days of these lines of endeavor in this country

and mainly identified with the agriculture of California. Born at Zweibrücken, Bavaria, January 5, 1833, Dr. Hilgard came to the United States as a child, but after finishing his elementary and preparatory schooling went back to Europe to study at Zurich, Freiburg, and Heidelberg. After returning to this country he was appointed chemist of the Smithsonian Institution in 1855, but resigned the following year to enter the service of the State of Mississippi, working mainly in the field of geology until 1873, when he accepted an appointment as professor of geology and natural history at the University of Michigan. This position he filled until 1875, when he went to the University of California, where he worked for more than 40 years as professor of agriculture and director of the experiment station. His work was not only helpful in building up the agriculture of the State, but it also made important contributions to soil physics and soil chemistry. Dr. Hilgard rendered service of national and international scope in various capacities, and in recognition of his numerous contributions to agricultural science honorary degrees were conferred upon him by several universities in this country, and he was granted awards of merit by different organizations abroad.

Dr. T. J. Burrill, professor of botany emeritus at the University of Illinois and connected with that institution practically since it opened its doors in 1868, died April 14, 1916, at the age of 77 years. He served continuously until his retirement in 1912 as professor of natural history, of botany, and of horticulture. From 1888 to 1903 he was also botanist of the experiment station. At different periods he was dean of the college of science, of the general faculty, and of the graduate school. He was vice president of the university from 1897 to 1912 and acting president for various periods aggregating nearly five years. Dr. Burrill was born at Pittsfield, Mass., April 25, 1839, graduated from the Illinois State Normal University in 1865, and later received the honorary degrees of M. A. and LL. D. from Northwestern University and of Ph. D. from the University of Chicago. He was a member of several scientific societies, serving them as an officer at various times, and author of numerous scientific articles, mainly along botanical and horticultural lines.

J. Nelson, biologist of the New Jersey station and known for his studies in oyster culture, died in February, 1916. E. Fulmer, head of the department of chemistry at the Washington station since 1893, was killed in a railway accident in February, 1916.

The deaths of Dr. Joseph H. Kastle, director of the Kentucky Experiment Station, and of Prof. William R. Lazenby, Dr. Albert J. Cook, and Prof. Clinton D. Smith, all at one time active in experiment station work, occurred shortly after the close of the year. The careers of these men are here briefly noted.

Dr. J. H. Kastle, director of the Kentucky Experiment Station, died September 24, 1916, at the age of 52 years. Dr. Kastle was born in Lexington, Ky., January 25, 1864, graduated from the Agricultural and Mechanical College of Kentucky in 1884, received his M. A. from the same institution two years later, and in 1888 took the degree of Ph. D. at Johns Hopkins University, where he made chemistry his major study. The same year he became the head of the chemical department of the Agricultural and Mechanical College of Kentucky, filling this position until 1905, when he was appointed Chief of the Division of Chemistry of the United States Public Health and Marine Hospital Service. This position he resigned in 1909, to accept the chair of chemistry in the University of Virginia, which he filled until 1911. On July 1, 1911, Dr. Kastle became officially connected with the Kentucky Experiment Station as the head of the newly established department of chemical research. At the death of Dr. M. A. Scovell he was elected director of the station and dean of the college of agriculture. He had a marked genius for original investigation, and during his connection with the Kentucky station he exerted a very potent influence in organizing and stimulating agricultural inquiry.

Prof. W. R. Lazenby, professor of forestry in the Ohio State University, died at Columbus, Ohio, September 15, 1916. He was born at Bellona, N. Y., December 5, 1850, graduated in agriculture from Cornell University in 1874, and took the degree of M. A. from the Iowa Agricultural College in 1887. He was instructor and assistant professor of botany and horticulture at Cornell from 1874 to 1881, professor of botany and horticulture at Ohio State University from 1881 to 1892, of horticulture and forestry until 1909, and of forestry until his death. He was one of the founders of the Ohio Experiment Station and became its first director, serving from 1882 to 1887. Professor Lazenby was an extensive writer on agricultural, more particularly horticultural and silvicultural subjects, and held membership in a number of scientific and agricultural societies, in most of which he was elected to official positions at different times.

Dr. A. J. Cook, for many years connected with the Michigan Agricultural College and Experiment Station, died in California, September 29, 1916, at the age of 74 years. Dr. Cook was born at Owosso, Mich., August 30, 1840, graduated from the Michigan Agricultural College in 1862, and received from that institution his master's degree in 1864 and the degree of D. Sc. in 1905. He also studied at Harvard University in 1867 and 1868. From 1868 to 1893 Dr. Cook was professor of zoology and entomology at the Michigan College, as well as curator of the museum from 1875 to 1893 and entomologist of the experiment station from 1888 to 1891. He was professor of biology in Pomona College, Claremont, Cal., from 1893 to 1911, when he

entered upon the office of State commissioner of horticulture, which position he held until his death. Dr. Cook was one of the early economic entomologists of the country, testing the value of kerosene emulsion as early as 1877 and of arsenites in controlling the codling moth in 1880.

Prof. C. D. Smith, connected with experiment station work for a long period of years, died August 5, 1916, at the age of 62 years. Prof. Smith, born at Trumansburg, N. Y., March 7, 1854, graduated from Cornell University in 1873. For short periods after graduation he followed teaching and the practice of law. He was appointed assistant agriculturist in the Cornell Experiment Station in 1890, became director of the Arkansas station in 1891, and held the positions of director of the Minnesota station and of professor of dairy husbandry in the Minnesota College from 1891 to 1893. From Minnesota Prof. Smith went to the Michigan Agricultural College as professor of agriculture and held this position until 1899. In 1895 he was also made director of the experiment station and in 1899 dean of the department of special courses and superintendent of farmers' institutes. In 1908 he accepted the presidency of the Louis Queiros School of Agriculture, of Sao Paulo, Brazil, but returned to this country in 1913 and devoted himself to the operation of his farm at Trumansburg, N. Y., and to the extension service of the New York State College of Agriculture at Cornell University.

SOME RESULTS OF STATION WORK.

The experimental work of the experiment stations of the various States covers a wide range of investigation and practical study, involving essentially the whole field of agriculture. While some of the energies of the stations are still devoted to control work in accordance with State law, the funds and time available for research are increasing from year to year, and the output of published material dealing with agricultural problems is of high interest and importance. As in previous years, reference is made below to some of the interesting results obtained during the year under report.

AGRONOMIC INVESTIGATIONS.

The results of 15 years' work with fertilizers on certain plats at the West Virginia station were summarized. In the course of these long-continued experiments a ton of barnyard manure applied alone gave an average crop increase of \$3.12 in value, while the application singly of a dollar's worth each of acid phosphate, nitrate of soda, and sulphate of potash gave an average increase in crop yields of \$4.36, \$0.34, and \$0.37 in value, respectively. The results indicated that in general the turning under of a leguminous or other

catch crop tended to reduce the yield increases derived from the use of complete fertilizer applications.

The factors influencing the protein content of the wheat kernel received careful attention at the Idaho station. In this work four varieties of wheat are used. The available nitrates are determined in the soil and in the wheat crop at intervals of 10 or 12 days, and frequent records are taken of soil temperature. Thus far the work indicates that the available soil nitrogen influences the composition of the wheat. For example, Red Russian wheat averaged 10 per cent of protein, but on the nitrate plot the percentage of protein was 15. Barnyard manure, dried blood, and other forms of nitrogen also showed the same effect. It was found that there may be a large variation in the amount of water applied to wheat without affecting the nitrogen content.

The factors causing the softening of wheat were made the subject of further study at the Colorado station. Particular attention was given to nitric nitrogen in relation to the composition of the kernel. It was found that water has little to do with the composition of the grain. Apparently nitrogen in any other than the nitric form has no effect on the quality of the wheat grain, but it may increase the yield. In this work the limits of irrigation water applied were 6 and 36 inches. The addition of nitric nitrogen to the soil, even to the extent of 40 parts per million, increased the total nitrogen in the wheat. It was found that flinty wheat is developed on soils containing an abundance of nitric nitrogen, while starchy wheat is produced where potash is added to the soil.

The Washington station is also investigating the problem of wheat composition, with particular reference to the influence of cultivation on the nitrogen content and yield of wheat. Cultivation seems to induce a higher content of nitrogen, large differences in the nitrogen content being brought about as a result of variation in cultivation. It appears that photosynthesis and the supply of plant food from the soil are the two determining factors of the composition of the wheat kernel. Under conditions not favorable to the assimilation of food materials from the soil the starch content is proportionately large. On the other hand, under conditions unfavorable to photosynthesis the nitrogen content may be unusually high. Summer fallowing was shown to increase the nitrogen content of wheat, but a variation in the amount of water within reasonable bounds had no effect on the nitrogen content.

The Minnesota station is studying the strength of wheat flour with reference to enzymes, physical constants, and characteristics of protein. During the year attention was given to peroxidases as a means of classifying flour grades. The amount of oxygen liberated from hydrogen peroxid in contact with the flour for 15 minutes was found

to be perhaps the best means of measuring the baking strength of flour. Incidentally, evidence was obtained of a group of enzymes which split the envelope of the starch granule, thus exposing the starch grains to the true starch-splitting enzymes.

The moisture relations of wheat and flour are being investigated at the North Dakota station. During the year special attention was given to the capacity of the milling products of wheat for moisture as compared with gelatin, starch, and other substances. It was found that well-developed kernels of wheat hold more moisture than poor kernels and that all flours, of whatever process, contain from 1 to 1.5 per cent less gaseous moisture than the wheat from which they were made. The starch of high-grade flour contained more water than that of low-grade flour. In a study of the absorption of water it was found that damaged and sprouted wheat reached a maximum of moisture content more quickly, but that the total water content was less than with good wheat. The absorption of liquid matter by flour appears to increase with the increase in the nitrogen content of the flour.

The Nebraska station has found that wheat gluten is an emulsoid colloid showing all the properties of this class of compounds. Gluten appears to absorb water from dilute acid solutions, thereby lessening its tenacity and ductility and becoming soft and gelatinous.

At the Oklahoma station a study was made of the starches of grain sorghums. Sorghum seed was found to contain from 55 to 64 per cent of starch, the highest percentage occurring in Feterita, milo maize, and Kafir corn. The grains of starch in sorghum seed are similar in shape to those in cornstarch, but somewhat larger in size. It is believed that some of the sorghums may furnish suitable raw materials for the manufacture of starch.

A study of the changes in cotton seed during storage was conducted at the Arkansas station. It appears that when cotton seed is ground the fat becomes hydrolyzed into fatty acids at a rapid rate, 85 per cent of it being changed within three weeks. Cotton seed obtained from seed cotton gathered dry and stored in a farm cottonhouse in lots not greater than 7,500 pounds did not undergo much change in composition for a period of three weeks. If cotton seed is allowed to heat the amount of free fatty acids increases quite rapidly. In samples of fresh cotton seed the quantity of free fatty acids was less than 2 per cent.

A study of the chemical composition of alfalfa at different stages of maturity at the Kansas station indicated that alfalfa cut in the bud stage had the largest ash and crude protein content and the smallest amount of crude fiber. In each successive stage the crude fiber and nitrogen-free extract increased and the protein and ash decreased. Expressed in pounds per ton, alfalfa cut in the earlier

stages was found to have more crude protein and less crude fiber. The largest amount of total nutrients was obtained when the alfalfa was cut in the bud or early bloom stage. The leaves were found to contain 2.5 times as much protein as the stems. Moreover, alfalfa cured in the sun had a higher protein content than that which was cured in the shade.

A study of cover crops at the Porto Rico station indicated that most of the soils of that island are deficient in humus and that, in general, decided benefit is shown by the use of cover crops. The best results were obtained with cowpea, jack bean, Mauritius bean, and pigeon pea. In young coconut groves velvet beans, jack beans, and cowpeas proved most satisfactory. In Porto Rico cover crops appear to make their heaviest growth and to serve their purpose best when planted in the spring or early summer.

The study of the effect of one crop on a succeeding crop was continued at the Rhode Island station. In 1913 buckwheat was grown on plats without fertilizer, following onions, rye, buckwheat, and redtop, after which 21, 21, 13, and 10 bushels of buckwheat per acre, respectively, were secured. These same crops were followed by buckwheat in 1916 in pot experiments, with the result that the yield was again best after onions and rye and least after redtop. In another experiment alsike clover gave the highest yield following potatoes and decidedly the lowest yield following red clover or a previous crop of alsike clover.

The Kentucky station made a study of the curing of blue-grass seed. It was found that for best results the seed should not be gathered when green, since the material may heat in curing and thus injure germination. It appears that the seed may preferably be collected between June 15 and 20. When blue-grass seeds are allowed to heat to a temperature of 140° F., even for a short time, they are worthless. In fact, it is recommended that the seed should not be permitted to reach a temperature above 122° F.

Further experiments on the relation of the cultivation of corn to yield were carried on at the Minnesota station. It was found that after the soil has been well prepared it is not necessary to practice deep tillage. The average yield of the hoed plat exceeded the highest yield obtained from any other plat, being 1.46 bushels more than that of the plat which was cultivated six times. The Nebraska station continued its study of close breeding in corn. In preliminary experiments by means of ear-to-row breeding four strains were obtained which have been inbred for seven years. The work has involved a comparison of inbreeding in which the pollen of the corn plant is applied to the silk of the same plant, with close breeding in which a composite sample of pollen obtained from plants within a narrow family is sprinkled on silks of one row. It was found that inbreeding

greatly reduced the vigor of the plant, a pronounced weakness being shown by the third generation. Close breeding, on the other hand, leaves the offspring almost normal.

At the Missouri station it was found that the temperature of silage when first put into the silo generally ranges from 75° to 95° F. The temperature rises from 3° to 15°, reaching a maximum within 8 to 12 days, after which the temperature slowly declines. Where sufficient moisture is present and the silage is well packed the highest temperature seldom exceeds 100° F. It appears that the greatest factor causing variations in the temperature in the silo is the amount of air contained in the silage, and that the material used in the construction of the silo has little, if any, influence upon the temperature of the silage.

Some interesting results were obtained at the Montana station in experiments in thinning potatoes. The aerial portion of the potato plant was thinned to one stalk in a hill. The most noticeable benefit derived from thinning was the decrease in the amount of culms. In most cases the total yield was greatest from unthinned rows, as was also the yield of marketable tubers. The quality of the crop, however, so far as size and uniformity were concerned, was much better in the case of the thinned rows. While the total yield was diminished by thinning, the quality of the marketable crop as a whole was greatly improved. In one instance the marketable tubers of thinned plants averaged 8.3 ounces in weight, while those of the unthinned plants averaged 5.4 ounces. In some experiments carried on in Fergus County thinning increased the yield of marketable tubers and also the total yield. Moreover, the size and shape of the tubers were much better than from the unthinned plants.

A study of methods of eradicating quack grass was carried on at the Minnesota station. In all of the rotations used in this investigation quack grass was completely eradicated when the field was carefully tilled from the beginning of August until the ground was frozen in the fall and again the next spring until time for planting potatoes. A four-year rotation gave an exceptionally favorable opportunity to combat quack grass and other weeds. The planting of fodder corn three years in succession and keeping it well cultivated proved a very efficient and economical method of eradicating quack grass. Good results also were obtained from growing buckwheat for three years on fall-plowed ground.

The water requirements of plants were under careful investigation at the Nebraska station. The work involves experiments with wheat, oats, corn, and other crops. An investigation of the possible adaptation of corn to different amounts of moisture has thus far given

negative results. Small, early varieties of corn, however, appear to have a lower water requirement. Much attention has been given to the error of observation in experiments with small cans. This error has been found to be largely due, at least in the case of corn, to starvation. The same amount of soil placed in large cans and mixed with sand gives the same results as in the small cans. In experiments to determine the effect of water requirement in different strengths of nutrient solutions it has been found that within certain limits the volume of growth increases with the density of the solution.

SOIL AND FERTILIZER INVESTIGATIONS.

The New York Cornell station continued its study of influences which affect the formation of nitrates in soils. It appears that certain crops exert an inhibiting action on the formation of nitrates. In certain instances the loss of available nitrogen in planted tanks was observed, indicating a transformation into the form of organic matter. Corn and certain other plants, however, appeared to have a stimulating effect on the production of available nitrogen. An increased production of ammonia was found to occur in solutions in which plants are grown and also a reduction of nitrates. An attempt is being made to determine whether the reduction of nitrates is due to an enzym not destroyed by boiling, which develops in the plants, or perhaps in the root hairs. Timothy appears to reduce nitrates as fast as they are formed except those which the plant uses for its own growth.

In a study of nitrification in alkali soils at the Colorado station preliminary tests of virgin soils showed no protozoa to be present; only two species of Paramecium were found in cultivated soils; and the number of protozoa in soils throughout the State appears to be extremely low. It is suspected that alkali may prevent the growth and multiplication of protozoa. Samples of soils were obtained from several States and compared with reference to their nitrifying powers with certain types of Colorado soils. Nitrification in the Colorado soils was found to be 600 times more active than in eastern soils. Essentially the same condition was found true for ammonification.

At the California station it was found that the most economical transformation of nitrogen into nitrate is accomplished by the soil flora with the so-called low-grade form of nitrogenous fertilizers, such as cottonseed meal, steamed bone meal, and garbage tankage. The high-grade forms of nitrogen, like dried blood and high-grade tankage and fish guano, proved not well suited to most of the arid soils of California. Incidentally it was shown that ammonium sulphate is the most readily available inorganic form of nitrogen. An investigation was made of the nitrifying powers under incubator

conditions of 40 humid and 150 arid soils. Unlike the results obtained at the Colorado station, it was found that the nitrifying powers of the soils of the arid region were no more intense than those of the humid region. The arid soils, however, appeared to have the power of nitrifying the nitrogen of ammonium sulphate and cotton-seed meal much more vigorously than do humid soils.

The New Jersey station continued its study of nitrogenous plant food in the soils. During the year the highest average yield of dry matter and nitrogen from the main crops was obtained from plats to which solid and liquid manure was applied in conjunction with nitrate of soda. With regard to the loss of nitrogen this appeared to be greater where manure and nitrogenous fertilizers were used together than where either was used alone. The results thus far obtained indicate that the denitrification of nitrates does not take place to any great extent in general farming, even when large amounts of barnyard manure are used. Through the use of green manure and stable manure it was found possible to maintain the nitrogen supply of a soil at a higher level than with nitrate of soda alone. It was concluded that a small or moderate green-manure crop will supply from 70 to 80 pounds of nitrogen per acre, which is considered equivalent to from 450 to 520 pounds of nitrate of soda.

The Montana station has given considerable attention during the past few years to the problems involved in the intense nitrification observed in certain soils. During the year about 3,000 determinations were made of both nitrates and nitrites on certain plants under experiment. On some of these plats no loss of nitrate was observed as a result of the cropping. It has also been shown that the addition of an alkali salt to the soil may cause a great increase in the amount of nitrate, in some cases producing a rise of nitrates from 240 to 3,750 parts per million. In some of the pots under experiment a gain of 4 per cent in total nitrogen took place within three months. A few spots have been found in different parts of the State which contain as high as 8 per cent of nitrate nitrogen.

The effect of nitrate of soda upon soils is receiving careful attention at the California station. It appears that when there is a large quantity of material to be nitrified in the soil, bacteria are very active and possibly support the activity of nitrifying bacteria, perhaps forming also a large amount of ammonia which is not absorbed by the soil. The plats which received nitrate of soda have shown a tendency to become impervious to water. Incidentally it has been found that sodium bicarbonate in the irrigation water becomes black alkali during the daytime under conditions of high temperature, changing again to the bicarbonate condition in the night. In studying the movement of nitrates in soils it was found that soluble materials diffuse laterally instead of going down, with the

result that between the irrigation furrows the nitrate and soluble salts accumulate and are not carried down to the roots of plants.

The Massachusetts station investigated the effect of sulphate of ammonia on soil. The absorption of ammonia from sulphate of ammonia solutions by soils increased with the increase in the concentration of the solution. Incidentally it was found that the absorption of dyes by these soils is very similar to their absorption of ammonia, more dye being absorbed from the more concentrated solution. Ammonium sulphate was found to exert a solvent action on the calcium in the soils but not on the sodium or potassium in the presence of sufficient quantities of lime. It is believed that the use of ammonium sulphate probably does not cause the accumulation of sulphates in soil.

The relation of sulphur to soils and crops has been made the subject of inquiry at the Ohio station. It appears that soils well supplied with organic matter contain more sulphur than soils with a smaller amount of organic residues. Like phosphorus, sulphur is distributed in larger amounts in the surface soil. The sulphur content of the soil is increased by the use of fertilizer materials containing sulphates. It has been found that the cultivation of silt loam for 16 years without the addition of fertilizers has decreased the total supply of sulphur. A 20-year average of the Wooster 5-year rotation fertility experiments showed that such phosphorus carriers as acid phosphate and dissolved bone black containing sulphates produced more corn, oats, and wheat than did bone meal and basic slag. Better yields of beans were obtained from the use of potassium sulphate and ammonium sulphate than with potassium chlorid and sodium nitrate. In both experiments the use of sulphur and hydrogen sulphid in pots increased the acidity of the soil but gave a greater yield of clover than untreated or limed pots.

The interesting discovery was made at the New Jersey station that when raw rock phosphate and sulphur are composted with soil the sulphur becomes oxidized to such an extent as to act upon the rock phosphate, rendering it available. Within a period of six months it was found that about 80 per cent of the raw rock phosphate was rendered available under experimental conditions.

A number of studies were made during the year on the relation of green manuring to crop yields and soil conditions. At the Utah station it was found that the temperature of manured and unmanured pots averaged practically the same during the period of study. The ammonifying power of the soil increased with the manure applied up to 25 tons of manure per acre, but the greatest increase per ton of manure was obtained in soil receiving 5 tons. The ammonifying power of the soils increased as the water was increased until 20 per cent of water was applied. The nitrifying power of the soil in-

creased as manure was applied up to 25 tons of manure. The nitrogen-fixing power of the soil was greatest in those pots which received at the rate of 10 tons of manure per acre. The maximum number of bacteria were obtained from soils to which 15 tons of manure per acre were applied. At the Mississippi station a comparison was made between green alfalfa and oat straw as a manure. The alfalfa was applied at the rate of 4, 8, and 16 tons dry weight per acre, and the straw at the rate of 2, 4, 8, and 16 tons per acre. In the case of the alfalfa the yields increased with the application, whereas with straw the largest yield was obtained from an application of 4 tons per acre and the yields were lowered by applying 8 or 16 tons per acre.

At the Virginia station several plats were maintained at one-half moisture saturation and various kinds of green plants were applied. A great increase of nitrates and bacterial counts was noted as a result of the green manuring. When cellulose was compared with green manuring it was found to cause the plants to turn yellow and to check the formation of nitrates. Similar results were obtained in pots containing a nutrient solution. All forms of green manuring increased the yield of corn and wheat, and in all cases an increase in the number of bacteria in the field under green manure was definitely shown.

The cause and nature of soil acidity is receiving attention at the Wisconsin station. It is urged that the failure of investigators to demonstrate that soils take up chemically equivalent amounts of different bases has been used as an argument against the existence of true acids as the cause of soil acidity. It was shown during the year that when conditions are properly controlled reactions due to soil acidity take place according to chemical equivalents. It is believed that the acid substances may be either of crystaloidal or colloidal condition and that their acid reaction is due to their chemical action and not to their colloidal condition.

The Michigan station is making a study of the freezing point as a means of measuring the concentration of the soil solution directly in the soil. It has been found to be very easy to determine the lowering of the freezing point of soils. In fact, it was found easier to induce solidification in the soil than in solutions. The lowering of the freezing point was determined in a large number of soils at both low and high moisture contents. In none of these soils, with the exception of very sandy soils, was the ratio of the lowering of the freezing point directly inversely proportional to the ratio of the water content, but the former was many times greater than the latter. Further investigation showed that these changes follow mathematical laws, that the lowering of the freezing point increases in geometrical progression, while the water content decreases in an arithmetical progression.

The study of the fixation of phosphoric acid by soils was continued at the Virginia station. Certain soils were found on which no growth takes place unless phosphoric acid is added. Thus far the best results have been obtained from the use of sodium phosphate, acid phosphate, and slags. The effect of these phosphates appears to be directly proportionate to their nonsolubility. The soils used in these experiments were found to fix 95 per cent of the phosphoric acid which was applied. It appears, however, that the phosphoric acid is fixed toward solvents but not toward plants, as was shown by the residual effect of the phosphoric acid. Iron and aluminum phosphates were found to be fairly available for plant growth. No evidence was obtained of acidity in soils due to the continued use of acid phosphates.

The Texas station devoted some attention to the oxidation of organic matter in soils. It was found that corn chops, rice hulls, wheat shorts, and wheat bran were oxidized to the extent of 72 to 81 per cent, as compared with 47 to 68 per cent for tankage and blood and 15 to 22 per cent for bat guano during a similar period of oxidation. Cottonseed meal appears to be rapidly oxidized, about 10 per cent in 1 day and nearly 30 per cent in 4 days. Soils in a very dry condition were found to favor the rapid oxidation of organic matter, while oxidation in saturated soils appeared to depend upon the character of the soil. Carbonate of lime had little or no effect upon oxidation in the soils under study. The Texas station also studied the moisture relations of a number of soils. It was found that the average quantity of water in soils after continued rains is about 58 per cent of the water capacity of the soil as measured in the laboratory. When soils were saturated to a depth of 14 inches they contained enough water to produce a crop of 12 to 19 bushels of corn or 156 to 234 pounds of lint cotton. Cultivation and manure were both found to increase the quantity of water held at the end of wet periods and to decrease the loss of water by evaporation.

The North Dakota station obtained some interesting results in the study and preparation of synthetic media suitable for the growth of soil bacteria. As a means of grouping these soil organisms a series of synthetic media of different energy potentials and prepared from compounds of known composition with only one source of nitrogen and only one of carbon is used. Silica jelly proved to be the best agglutinin for the media. It was found that microorganisms showed pronounced selective tendencies toward particular forms of nitrogen and carbon needed for their growth.

An elaborate study of the effect of dynamite upon soils was conducted at the Kansas station with reference to the effect on yield, moisture content, nitrate development, bacterial flora, and physical condition of the soil. The yield of corn in most instances showed

no differences greater than would occur on two areas of soil similarly treated. Likewise, moisture determinations on nine dynamited and four undynamited plats extending over a period of three years showed no marked difference in moisture content of the soil. Again, dynamiting the soil appeared to have no effect upon nitrification. In a few instances the number of bacteria was somewhat larger on dynamited soils in the surface foot. In the case of heavy clay soil a compacting and puddling was noted, leaving the soil in poorer physical condition than before dynamiting was done. Fruit trees planted on dynamited soil made a slower growth than did trees planted on similar adjoining soil which had not been dynamited.

ANIMAL HUSBANDRY.

In a study of steer feeding as related to farm returns at the Tennessee station it was found that soy beans and barley ranked ahead of other combinations used in various rations. The rotation in which soy beans were used produced on an average 57 pounds more beef per acre than did cowpeas and 74 pounds more than corn. The Georgia station found that a more efficient utilization of the nutrients was made by steers when a maximum amount of silage was fed with a minimum amount of cottonseed meal. It was observed that when silage is fed alone steers masticate it more completely than when it is fed with cottonseed meal. It was also noted that digestion was more complete with the more rapid passage of food through the intestines.

A study of the ration and age of calving as factors influencing the growth and breeding qualities of cows at the Missouri station showed that a heavy ration resulted in a more rapid growth of skeleton, especially during the period of most rapid development. The influence of age at first calving was rather pronounced as regards the size of the cows. Incidentally it was shown that milk production is a severe tax upon the cow and checks growth to a marked degree. Heifers which received a heavy ration during growth were slightly inferior in milk production to those which received a light ration. It appears possible to influence the rate of growth, size at maturity, and type of cows to some extent by liberality in rations during the growing period, but the character of the ration appears not to exert any appreciable effect upon the milking functions of the cow when mature.

The Wisconsin station continued its study of the nutritive deficiency of wheat and grain mixtures. It was found that malnutrition is characterized histologically by nerve degeneration and may result from the absence of certain factors in the diet. A large mass of wheat in the ration of swine exercised a toxic effect, even in the presence of all the recognized factors for growth. No one important

factor for growth, such as better proteins, or salts, appeared able to correct this toxicity. Excellent supplementary materials were found, however, in alfalfa and commercial meat scraps, even in the presence of the toxicity of wheat. The Connecticut State station also made further progress in its protein studies. It was shown that with approximately equal intake of food, essentially equal gains in weight were made by rats receiving 8 per cent of lactalbumin, 12 per cent of casein, and 15 per cent of edestin, respectively, in their food. With chickens it was shown that a food deficient in the amino acid lysine fails to promote growth.

Further progress was made at the Ohio station in a study of the mineral metabolism of cows. Liberal milk production on common winter rations fed in quantities sufficient to maintain live weight and cause regular nitrogen and sulphur storage caused losses of calcium, magnesium, and phosphorus from the skeleton. The cause of the inadequate utilization of minerals, especially calcium supplied in the ration, is considered as requiring further investigation. An excess of inorganic acids over bases in a ration, due largely to the silica of timothy hay, caused an acid reaction.

The Mississippi station continued its studies on the economy of mule production. At the usual prices for feeding stuffs it appeared that small mules could be produced at a profit of \$28.62 per head, cotton mules at a profit of \$35.38, and heavy mules at a profit of \$55.48. The study of deficient horse rations was practically brought to a close at the South Dakota station. In this work it was found that navicular disease, sidebones, spavins, and other bone diseases and deformities may result from deficient feeding. All the horses developed navicular disease and the bone structure was found to be greatly wasted. Many cases of ankylosis were found and adhesions occurred in the intestines.

The Montana station developed greater accuracy in methods for testing wool. It was found necessary to determine the relation of humidity to the size and strength of the wool fiber. Unless a statement is given concerning the humidity of the air in tests of wool strength it appears impossible to correlate the results of one investigator with those of another. The diameter of the wool fiber is increased with a rising humidity, but the strength is diminished in proportion to the size of the diameter.

POULTRY INVESTIGATIONS.

At the Utah station the data secured in breeding for egg production since 1907 were summarized. A striking climatic influence of different seasons was noted, but the cause of this phenomenon has not been found. The season also appears to affect the incubation of eggs and subsequent growth of chicks. It is believed that breeding for

egg production must be carried over a period of at least three years to get reliable records of mother hens. The Maine station has kept exact laying records in its breeding experiments on nearly 5,000 hens. From the beginning of the experiment until 1908, when mass selection was changed to selection on a progeny test basis, the general trend of production was downward, but since that year there has been a steady increase in winter egg production for the whole flock, with two slight exceptions. It is considered, therefore, that selection on the basis of a progeny test is effective in increasing egg production.

The effect of inbreeding was studied at the Wisconsin station. In this work an arbitrary character (white color) having no apparent relation to the vigor of the fowls was chosen. The experiment has been in progress since 1913. Inbred fowls have been found to show a decrease in egg production and in the hatchability of the eggs, while check pens of fowls show no such falling off. This study appears to show quite clearly a specific weakening effect from inbreeding. At the Oregon station a comparative test was made of incubation in a dry and moist incubator and under hens. The chicks at the piping stage were killed and studied by chemical analysis, and also with reference to their anatomy. In chicks from the dry incubator the yolk sack had not been properly absorbed. Chicks from the moist incubator weighed at the time of hatching as much as or more than those hatched under a hen. The percentage of chicks hatched was slightly in favor of the moist incubator. In the dry incubator the development of chicks was less complete; otherwise the differences were very slight.

A comparison of meat scrap, fish scrap, and skim milk for laying pullets was made at the Indiana station. On the skim-milk ration pullets laid slightly better in December and January. It was found that Leghorn pullets would consume about 93 pounds of skim milk per year. It cost 8.5 cents to produce one dozen eggs in the meat-scrap pen and 9.7 cents in each the fish-scrap and skim-milk pens. A greater profit was shown from pullets fed skim milk than from those on other rations. The limitations of cottonseed-meal feeding in poultry were investigated at the North Carolina station. It appears that cottonseed meal in a dry mash constituting 10 per cent of the mixture for laying and breeding stock shows no noticeable effect, at least during a period of 90 days. When, however, cottonseed meal constitutes 20 per cent of the fattening ration it proves unpalatable and the birds make unsatisfactory gains, sometimes even losing in weight. In all the tests it was noted that fowls became sick when cottonseed meal was consumed to the extent of 1 ounce or more per day. The effect of withholding the lime supply from hens was studied at the Wisconsin station. When the amount of lime was reduced the number of eggs was correspondingly reduced, but the shells

were no thinner than under normal conditions. Soft-shelled eggs appeared not to be a matter of nutrition but a result of some other condition in the hen.

The Massachusetts station is studying broodiness in poultry. Breeding experiments to secure a nonbroody strain of Rhode Island Red fowls were continued with promising results. Matings of one male in 1914 with nonbroody hens gave only nonbroody pullets. The Rhode Island station continued its investigation of the bacterial infection of eggs. Of 2,520 fresh eggs 8.7 per cent showed bacterial infection in the yolk. None of the whites of 111 eggs examined was infected, while the yolks of the same eggs were infected to the extent of 4.5 per cent. No correlation was observed between percentage of infection and hatchability of the eggs or fecundity and age of the hens or season of the year. The percentage of infection for infertile and fertile eggs was practically the same.

Bacillary white diarrhea in young chicks was the subject of further investigation at the Massachusetts station. In all the districts of Massachusetts which were investigated for this purpose the disease was found to prevail to some extent, in certain flocks up to 50 per cent. It has been found that the infection is readily transmitted through eggs, day-old chicks, or mature stock. Wherever the blood test was made and the positive reactors eliminated a marked improvement was shown in the young chicks hatched thereafter. The Nevada station made further progress in the study of epithelioma of chickens. Vaccination with virus gave good results when two injections were made. In 5 flocks containing 3,062 birds, of which 45 per cent were visibly affected, the spread of the disease after vaccination was negligible. The method has been applied to about 58,000 fowls with a mortality of 8.24 per cent. A secondary infection has given some trouble, but it is expected that this will soon be overcome.

DAIRYING.

A thorough study of milking machines is being conducted at the South Dakota station. In this work seven types of milking machines are in daily operation, attention being given to the effect of the milking machine on the length of the lactation period and on the total milk yield. Some of the cows in the experiment have been milked by the same type of machine for six years. No bad effect on the udders was observed from the use of milking machines. The conclusion has been reached that the success of the milking machine depends as much on the cow and operator as on the machine, since some cows can be successfully milked by any machine while others are not suited for the use of machines. In case of cows in which the front quarter of the udder is higher than the hind quarter the front

quarter is first exhausted, resulting in the establishment of a vacuum causing some pain. Such cows are not adapted for milking by machine.

The study of the nutritive value of milk was conducted by the Vermont station, using young pigs as experimental animals. The grades of milk were based on the percentage of fat, the size of the fat globule being also taken into account. It was found that a relatively low fat content is best, but that the size of the fat globule is of little importance. Further progress was made by the New York State station in its investigation of the germ content of stable air in relation to the contamination of milk. When cattle were maintained in the station stable the germ content of the stable air was usually about 50 to 100 per liter; in the stable loft after a heavy dust was raised by sweeping up débris on the floor the germ content of the air ranged from 1,000 to 2,000 per liter. When 5 liters of milk were left standing in an open 12-inch pail in the stable for one hour it was found that the number of bacteria thus added to the milk ranged from 96 to 199 per cubic centimeter. The air of the stable is considered as being a practically negligible factor in the contamination of milk.

The New York State station also investigated the chemical changes which occur in the souring of milk. It was found that most of the change in milk occurs between the tenth and twenty-fourth hours, and that when the amount of lactic acid reaches 0.7 per cent the bacterial activity is much reduced. Metallic flavor in dairy products has been made the subject of study at the New York Cornell station. It was learned that dairy products may directly absorb metals, thus acquiring a metallic flavor. Bacteria, however, were also found to cause a metallic flavor. In 241 samples of cream in sterilized glass bottles the metallic flavor was produced in 79 by inoculation with metallic-flavored buttermilk. The organism which causes this metallic flavor is a strain of the *Bacterium lactis acidi* group. The Iowa station has given much attention to slimy andropy milk. Cultures of organisms secured from slimy starters, apparently typical *Streptococcus lacticus*, sometimes showed marked capacity to produce ropiness. The associative action of organisms was shown to be responsible for ropiness in some cases, since two organisms—neither of which alone produces ropiness—might bring about this condition when growing together.

ENTOMOLOGICAL INVESTIGATIONS.

On account of the extensive destruction of buds of 1-year and 2-year old fruit trees, the Washington station investigated the insect pests causing this damage. They were found to be wingless weevils which could be prevented from destroying the buds by the use of

paper cone tree protectors. The Maine station continued its investigation of aphids, giving particular attention to the pink and green aphid of the potato. This insect was found in the spring upon rose bushes feeding on the succulent growth near the flower buds. Migration to the potato plant occurs either through wingless or winged individuals during the first half of July. By the middle of September the fall migration occurs, the aphids at that time deserting the potato fields. The life history of various species of plant lice is also receiving attention at the Colorado station. Special emphasis has been laid on woolly aphis, green apple aphis, and black peach aphis. The green apple aphis has been found to live on the apple and crab in winter and to attack red clover in summer.

At the Alabama station the life history of the fall army worm was studied with reference to rational methods of control. Outbreaks of this pest usually follow overflows or winters of heavy rainfall. The insect feeds on a large variety of plants. The special enemies of the pest multiply rapidly with the succeeding generations. The most effective cultural practice was found in light, shallow cultivation during the pupal period; a single harrowing destroyed from 35 to 50 per cent of the pupae. The velvet bean caterpillar has been found to be the most serious enemy of this plant at the Florida station. The insect does not survive the winter in northern Florida, but fields appear to be reinfested each summer by moths coming from the extreme southern part of the State or possibly from Cuba. Good results can be obtained from growing, therefore, crops of early varieties of velvet beans which are to be sprayed or dusted with arsenate of lead. The Kentucky station continued its investigation of the locust borer. The adult beetles were found to feed almost exclusively on the pollen of goldenrod, particularly *Solidago altissima*. Since the adult insects appear to be dependent on this pollen and are abundant only where it can be secured, it is suggested that goldenrod in the vicinity of locust plantings be destroyed or heavily sprayed with arsenate of lead in early September.

The Minnesota station is conducting a study of the toxicity of insecticides. The experiments have involved the use of various insecticides in bottles, in which house flies and other species of flies were placed. It was found that nitrobenzene kills house flies more quickly than bluebottle flies. In comparing the toxicity of various benzene compounds the orthobenzene compounds were found to be most poisonous, while the inverse order of toxicity was noted with respect to plants. Incidentally it was observed that goats, sheep, and dogs can bear without serious harm fumigants which will kill fleas, ticks, and other insect pests of these animals. A study of arsenical sprays at the Oregon station showed that a mixture of arsenic and lampblack or fuller's earth has a high killing power for insects,

without producing much burning effect upon foliage. During the course of these studies a pure calcium arsenite was prepared in the laboratory for testing as a spray on roses and apples.

HORTICULTURAL INVESTIGATIONS.

In experiments carried on by the Oregon station, summer pruning of a dwarf orchard of 5-year-old trees well adapted to the work was found to exert no visible influence upon the development of fruit buds on old spurs and actually reduced the number of fruit buds on 1-year-old wood. The practice did not affect the rate of development of axillary buds except those on the current growth immediately below the cut, where potential fruit buds were stimulated to the development of flowers. Buds once differentiated as fruit buds were found not to revert readily to shoot growth as a result of summer pruning. The apparent superiority of summer pruning over dormant pruning alone in the production of fruit spurs on the current season's growth is attributed largely to the fact that on normal shoots not summer pruned many of the potential spurs are removed at the time of dormant pruning, whereas with summer-pruned shoots the resulting secondary shoots carry potential spurs practically as far advanced as those from shoots not summer pruned and are in such a position on the tree that they are not removed at the time any needed dormant pruning is given.

At the Virginia station it was found that spring pruning of the branches of trees at the time of growth somewhat checked the formation of fruit buds. Pruning during the latter part of June, when buds had begun to show differentiation, checked the wood growth during the year but greatly stimulated the formation of fruit buds. The crop of fruit buds was not materially influenced by fall pruning.

The New Hampshire station made a systematic study of the means of controlling fruit-bud formation on the apple. A periodicity in growth was observed which is confined to a short time, after which, in July, an almost absolute period of rest begins. A second period of fruit-bud formation the latter part of summer and early fall was evidenced by fruit buds formed on the terminus of the second growth. Large leaves appear to increase the storage of reserve material and the formation of fruit buds. In trees bearing in alternate years a larger amount of starch was found in twigs which had formed fruit buds than in twigs carrying only leaf buds.

In the investigation of winter injury to trees at the Nebraska station an attempt is being made to determine the critical temperatures at which apple stocks are injured. It was found that most of them are killed or injured by temperatures ranging from -10° to -15° C.

In this work about 100 varieties were used. In some cases the stock roots were killed, while the scion roots were uninjured. An attempt is being made to correlate soil moisture and temperature conditions with the relative degree of freezing of the apple stocks. At the New Mexico station the vinifera grape was found not to be as resistant to winter temperature as the native varieties. When the soil was banked up around the vines an adequate winter protection was afforded. Irrigation either before or after the vines were laid down and covered appeared to have no effect upon the susceptibility to winter injury.

In a general study of orchard culture at the Pennsylvania station it has been found that the mulch treatment is quite efficient in improving the yield, growth, and size of fruit in orchards up to 20 years of age, while the sod treatment has usually given unsatisfactory results. Tillage appears to be beneficial in fully matured orchards, while cover crops have not generally given any benefit. The color of the fruit seems to be primarily brought about by sunlight in the later stages of maturity. A study of apple storage at the Idaho station has involved a thorough investigation of the biochemistry of the apple. An attempt is being made to find a physical measure or indicator of the changing composition and condition of the apple. It has been found that acidity in the apple decreases in low temperatures. The influence of temperature on the hydrolysis of starch is also under investigation.

The Missouri station continued its elaborate study of the rest period in plants. The results of respiration studies and other tests indicated that the specific effect of all rest-breaking agents on dormant woody tissue is the stimulation of enzymes. The experimental evidence also indicates that diastatic, proteolytic, fat-splitting, and oxidizing enzymes are induced to become active by treating twigs with ether or other agents. It appears, therefore, that the rest period sets in on account of the inhibition of enzym activity due to the over-accumulation of the products of their work.

The New York State station has been studying the economic status of dwarf apples during the period of 10 years under widely varying climatic and soil conditions. It has been found that dwarf apple trees come into bearing little, if any, earlier than standard trees of the same varieties, and that the amount of fruit produced is too small to make the difference in bearing age of any commercial value.

An extensive series of spraying experiments at the Illinois station showed that even under the most unfavorable circumstances some degree of benefit resulted from the application of all standard sprays to apple trees in every series of experiments and in every year of the experimentation. The smallest control exercised over apple scab with Bordeaux mixture was 67 per cent, and the largest amount of

control was 98 per cent. Lime sulphur was almost equally beneficial and did not cause as much russetting of the fruit. The codling moth was invariably controlled to some extent by the use of arsenate of lead, although the effect on the curculio was less pronounced. Paris green proved less effective than arsenate of lead in controlling codling moth and plum curculio and caused considerably more burning of the foliage.

The New York Cornell station conducted a number of experiments in dusting and spraying apples. It was found that a reduced quantity of arsenate of lead in a dust mixture may be depended upon to give good results. In one orchard the codling moth was more decidedly controlled by dust than by liquid applications. Finely ground sulphur furnished an effective means for controlling apple scab and sooty blotch. The same material in a dust mixture proved as efficient a fungicide as lime-sulphur solution in the control of leaf diseases in nursery stock. At the Virginia station a hydrated lime and sulphur spray gave very promising results. It was found necessary in preparing the spray that the sulphur and hydrated lime should be sifted after mixing them and before adding the boiling water, and that the spray must be kept thoroughly agitated during the process of application.

BOTANICAL INVESTIGATIONS.

Further progress was made in the study of the toxic effects of copper compounds upon crops at the Arizona station. It was found that the toxic effect of copper is exerted at the growing point of the root system. Apparently the copper unites with the proteids at that point. The effect of copper in soil cultures is much less pronounced than in water cultures. A few plants showed a slight stimulating effect of very dilute solutions of copper. The supposed stimulating effect of Bordeaux mixture upon plants was further studied at the Vermont station. The results of this investigation indicated that the apparent stimulation is largely due to the control of flea beetles and tip burn. The Vermont station also investigated forcing the plants with carbon dioxid. In this work radishes, strawberries, nasturtiums, potatoes, and lettuce were used. It appears that carbon dioxid applied above ground was beneficial in all cases. Apparently the carbon dioxid acted as a stimulant and hastened the maturity of the plants. In an investigation of frost resistance in cacti at the Arizona station attention was given particularly to spineless forms of cacti. It was found that hardness or resistance to frost is a quality which resides in the protoplasm and differs with different species. The thickness of the skin is found to be also a large factor in hardiness.

At the Porto Rico station the immobility of iron in plants was studied with reference to the utilization of iron in plant physiology. The results obtained in this study indicate that iron is relatively immobile in the plant after it has once been transported to the leaves, being similar in this respect to silica and calcium, and different from nitrogen, phosphorus, potassium, and magnesia. It was found that the iron is seldom or never transferred from leaf to leaf, at least in the case of the rice plant, even where the plant was insufficiently supplied with iron. The Maryland station continued its investigation of the relation of catalase and oxidases to respiration in plants. It was shown that the oxidase content in potato juice gives no indication of the intensity of respiration in the tubers, while the catalase activity in the potato juice showed a striking correlation with respiratory activity in the tubers.

INVESTIGATIONS OF PLANT DISEASES.

The relation of parasitic fungi and bacteria to their host plants was studied at the Virginia station. Numerous observations were made to determine the effect of temperature and moisture on the germination of rust spores. For use in this experiment a special spore trap was devised to show the rate of dispersal of rust spores. It was found that a rainfall of four hours or more is necessary to cause the discharge of spores from cedar galls and that following such a rainfall the spores are discharged for a period of only about one hour. The chemistry of disease resistance has been made the subject of study at the Minnesota station. Wheat rust has been found to be more serious if it attacks the stem than when it merely attacks the leaf. Wheat plants were, therefore, stripped at flowering time and carefully studied with reference to their chemical composition at weekly intervals. It was found that photosynthesis is fully as active in the stems as in the leaves. Incidentally it was noted that rust infection causes a great increase in respiration in wheat plants.

The Washington station made further progress in the study of wheat smut. It appears that this disease can be controlled only by the combined use of various practices, including crop rotation, the use of smut-free seed, the careful treatment of the seed, and early or late seeding. Evidence was obtained that the smut spores are distributed in so-called showers. Replowing of summer fallow was found to reduce the amount of smut if this operation and seeding took place after the first fall rains. It is suggested that the reason for the occasional failure of the seed treatment for smut when applied in the fall is that the wind carries the heavy infection of spores, thus reinfecting the fields. In the spring, however, seed treatment has given more satisfactory results.

The Idaho station has begun a study of the yellow rust of Europe which was recently found in Idaho and elsewhere. The fungus appears to be particularly common and injurious on a Russian wheat grass which had been introduced upon the station grounds. The rust occurs on the leaves, stem, and glumes of the wheat grass, but only on the leaves of the wheat. It has also been found on emmer. The strains of Turkey wheat have been found to be less susceptible than most other varieties.

Methods of controlling cotton anthracnose are under investigation at the South Carolina station. As a result of these investigations it is recommended that old seed be planted after treatment with hot water or with sulphuric acid. It has been found that the fungus does not retain its vitality in seed 2 years old or older. At the Louisiana stations it was found that the bean anthracnose fungus exhibits a number of different strains, affecting different bean varieties in an unlike manner. The cotton anthracnose, however, was not found to show any varietal differences and no marked variability was found in varieties of cotton in their resistance to anthracnose.

An investigation of plum wilt at the Georgia station showed that this disease is due to a species of *Lasiodiplodia*, which infects principally the conducting tissue of the trees, causing gummy formations. Apparently the fungus can not enter through unbroken bark, but only through wounds. Careful attention to wounds will therefore partially control the spread of the disease. The red rot of conifers was found by the Vermont station to gain entrance to trees largely through broken branches. No evidence was obtained of root infection. Prevention of the disease can apparently best be accomplished by suitable thinnings and the removal of diseased trees and fruiting bodies of the fungus.

The Wisconsin station studied the late blight of potatoes with reference to the germination of the spores of *Phytophthora* and the conditions of infection. It was found that the spores germinate either indirectly by the production of zoospores or directly by germ tubes and that temperatures below 20° C. were favorable for indirect germination. It was noted that a frost which will kill the tissues of the host plant will also destroy the conidia of *Phytophthora*. Potato plants which were chilled for from 12 to 24 hours were rendered more susceptible thereby. Infection with the disease became visible within two or three days. The foliage was infected only when direct germination of the spores occurred and took place more commonly on the under than on the upper surface of the leaf.

The Nebraska station continued its investigation of *Fusarium* as connected with dry rot of potatoes, separating two species of *Fusarium* on a physiological basis. One of these species is active

in field and the other in storage. The species which is active at low temperatures causes rot only in cold storage, but both species may cause wilt of the foliage or under other conditions cause rot. The diseases of sweet potatoes were under investigation at the Delaware station. It was found that black rot is carried with the seed to the seed bed and from there to the field. Corrosive sublimate gave better results for seed treatment than did formaldehyde in controlling the diseases of the sweet potato which are carried with the seed. A solution of formaldehyde, however, at the rate of 1 pint to 20 gallons of water and used at the rate of 1 gallon to 1 square foot of soil thoroughly disinfected the seed bed.

The Washington station continued its study of tomato blight. The disease appears to be caused by *Rhizoctonia* and apparently the same species of fungus causes a similar disease of potatoes. The fungus occurs on about 20 host plants, including beans, carrots, peas, and various species of Solanaceæ. Apparently tomato blight is more active in acid and infertile soils. Tomato plants, if set deep in the soil, endure attacks better than when planted shallow. Tomato-leaf diseases were also the subject of study at the Maryland station. In a few instances indications were obtained that lower concentrations of various chemicals than those which cause injury to the plants somewhat reduced the development of leaf parasites. In this work a large number of chemicals were employed. It was shown that mercuric chlorid, sodium nitrate, barium nitrate, and oxalic acid did not prevent the development of *Septoria* even on plants which showed injury from the chemicals. In general, it was found that tomato plants, to the roots of which various chemicals in various strengths were applied, sometimes developed less leaf disease than without the use of chemicals, but the differences were not important.

Further work was done on citrus canker at the Florida station. This disease has proved to be a serious one for most of the varieties of citrus grown in the State, all parts of the trees above ground being infected. High temperature and high humidity favor a rapid development of the disease. It was found that the bacteria are capable of growing in sterilized soil and of retaining their vitality for long periods in such soil. The New Mexico station, in experiments with iron sulphate for the treatment of chlorosis, found that orchard trees which had had iron sulphate placed in borings in the trunk indicated a beneficial effect, while spraying chlorotic pear trees with a 1 per cent solution of ferrous sulphate gave no appreciable result. At the Hawaii station, iron sulphate used as a spray on chlorotic pineapple growing on highly manganiferous soil induced a prompt greening of the foliage, and plants which received six sprayings yielded more than six times as much first-class fruit as unsprayed lots of similar character, the total cost being about \$3.60 per acre.

VETERINARY INVESTIGATIONS.

Swamp fever of horses was under investigation at both the Wyoming and North Dakota stations. In Wyoming interesting results were obtained in a study of the transmission of swamp fever by biting flies. By the use of screened cages it was quite clearly shown that stable flies may transmit the disease from one animal to another. Swamp fever appears to be due to a filterable virus. The stable fly is apparently not a necessary host of the virus but merely a carrier.

At the North Dakota station experiments were made with injections of the extract prepared by macerating bot-fly larvae in salt solution. This extract proved to be extremely toxic, some horses being killed within 40 minutes. Moreover the blood from dead horses reproduced the disease in healthy horses. Agglutination and complement fixation tests were repeated again without result. The cause of swamp fever has not yet been definitely determined, but it is believed that the disease produced by the extract of bot-fly larvae is not the same as swamp fever.

Goiter and hairlessness in pigs and other animals was actively studied at a number of stations, including Wisconsin, Montana, and Washington. In Wisconsin it was found possible to produce hairlessness at will by the use of defective rations. In Montana beneficial results were obtained from the administration of potassium iodid in the rations of sows. At the Washington station it was found that big neck of calves and hairlessness of pigs occur quite generally in various parts of the State. It was, however, impossible to determine with certainty whether the cause of hairlessness and of the enlargement of the thyroid gland is the same. The evidence thus far indicates that the trouble is one of nutrition, and that hairlessness and goiter are not necessarily associated. Experiments are under way to determine whether tincture of iodin applied to cows will be of any effect in preventing the disease in calves.

A study of cottonseed meal toxicity was continued at the Georgia station. It was found that 100 grams of cottonseed meal contained an excess of acid-forming over base-forming elements equivalent to 8.21 cubic centimeters of normal acid. A dose of 25 grams of cottonseed meal per kilogram of live weight daily for 6-weeks-old pigs produced fatal effects within 30 to 40 days. The injury was manifested before death by constant, abnormal, physical, and metabolic processes. The use of ferrous sulphate in the ration retarded the injury, but it was concluded that acidosis plays only a small part in the toxicity of cottonseed meal. At the North Carolina station further evidence was obtained that gossypol is the toxic principle in cottonseed meal. Seed from which gossypol had been extracted was

found to be no longer toxic to rabbits, while the extract was extremely toxic.

Interesting results were obtained from a study of avian tuberculosis at the North Dakota station. It was found that the mammalian tubercle bacillus produces an extreme emaciation in fowls as well as in English sparrows, without, however, producing any lesions. The fowls and sparrows carry pathogenic tubercle bacilli, and are therefore to be considered as important agents in spreading the disease. At the North Dakota station encouraging progress was also made in the study of hog cholera. It was found that the antigenic quality of the serum is more easily destroyed than its pathogenic property. It was found that serum kept in a refrigerator for six weeks retained its potency and that potency was also maintained for 212 days at room temperature. It is suggested, therefore, that good quality of serum may not be destroyed by freezing or putrefaction.

In continuing the study of contagious abortion at the Connecticut Storrs station attention was given chiefly to complement fixation and agglutination tests. Reactions were obtained in animals of all ages. It was found that calves from reacting mothers are themselves reactors at birth but that in three to five months they invariably become nonreactors and remain so for several months. At the Vermont station the study of complement fixation led to the discovery of certain guinea pigs which possess no complement. These animals were bred to determine whether the quality was inherited. Apparently the absence of complement is hereditary. In mating hybrids with hybrids about 56 per cent of the resulting offspring are normal and about 44 per cent without complement.

The relation of the agency of insects in carrying anthrax was studied at the Louisiana station. It was found that anthrax may be carried from infected guinea pigs to healthy ones by the horn fly. The disease was also transmitted in the same manner from infected sheep to guinea pigs. Similar results were obtained with the horsefly and with some of the swamp mosquitoes. Incidentally it was observed that anthrax bacilli are destroyed in the digestive tract of the horn fly.

Further work was done on sarcocystis in sheep at the Wyoming station. It was shown that the sheep was an accidental and not a definitive host of the parasite. A series of feeding experiments were carried out with lambs in which the lambs were fed various species of insects, grasses, and forage plants, and were given drinking water containing sarcocystis. Infection was almost invariably produced by feeding the lambs certain moths and butterflies and their larvae. Infection was also brought about by feeding grass presumably carrying these insects. The chemical investigation of *Delphinium glau-*

cum at the Wyoming station was completed. It was found that the plant contains a complex water-soluble alkaloid which readily splits into two, one of which is very poisonous, while the other fraction of the alkaloid is slower in its action. The alkaloid is not crystalline but amorphous and becomes less soluble in old plants in the fall of the year.

INSPECTION OF THE STATIONS.

In accordance with the usual practice of the office, a personal examination on the grounds was made during the year of each of the experiment stations receiving Federal funds. These official visits served as the means of securing a large amount of first-hand information in regard to the progress of the stations and their relations to the colleges with which they are connected and to the agriculture of the States, as well as for a detailed examination of their work and accounts; and the opportunity was embraced for conferences with the station officers in regard to organization and administration. This inspection was participated in by five members of the office force—the chief (E. W. Allen), E. V. Wilcox, J. I. Schulte, Walter H. Evans, and W. H. Beal.

The following reports upon the several stations are based on the results of this visitation, together with the annual financial statements of the stations, rendered on schedules prescribed by the Secretary of Agriculture, and the printed and other reports received from station officers.

ALABAMA.

Agricultural Experiment Station of the Alabama Polytechnic Institute.
Auburn.

J. F. DUGGAR, M. S., *Director.*

A number of changes occurred in the staff of the Alabama station during the year. J. S. Caldwell went to the Washington station in December and was succeeded by W. J. Robbins. F. A. Wolf, plant pathologist, resigned and his position was filled by the appointment of G. L. Peltier. It is planned to carry on less work under the support of the Adams fund in the departments of agronomy and horticulture and to increase the allotment of this fund to the departments of botany and plant pathology. The fund for local experiments available to the station was \$27,000 and the sales fund amounted to \$3,000. About 70 acres of land are used for experimental purposes at the main station and cooperative experiments in various parts of the State involve the use of much larger areas. Appropriations were made for a new serum plant to cost \$25,000 and for \$3,000 to be used annually for the maintenance of this plant.

Adams fund projects.—The agronomy department continued its experiments in breeding cotton, corn, and oats. In this work particular attention is being given to the correlation between characters. The data secured with corn were compiled and the correlation coefficients for a number of characters were worked out on several thousand ears of corn. Less progress was made in the study of correlation of cotton characters. In the oat-breeding work some valuable strains of this plant have been secured and propagated on a considerable scale. A strain of cotton was also obtained yielding 48 per cent of lint, and also a wilt-resistant variety of cotton of good quality. A large amount of hybridization work was done in connection with these experiments. The wilt-resistant varieties of cotton used in the tests differ slightly in relative earliness, but most of them are comparatively late in time of opening. The strains which rank highest in money value of seed and lint are earliest. In controlling wilt and root knot a simple rotation of crops is recommended in which crops susceptible to the disease are excluded.

The effect of certain southern feeds on the properties of lard was studied with particular reference to peanuts as a pasture crop and as a dry-lot feed. Different lots of pigs were fed rations containing peanuts in different proportions, while one lot received peanuts deprived of oil. Moreover, another lot of pigs was fed on oil-free cottonseed meal to supplement previous experiments in feeding that product. All the meats and lard were subjected to chemical study and analysis.

The investigation of peanut diseases was concluded. It was found that rotation is not effective under field conditions in eliminating leaf spot. A field in which peanuts had not been grown for 11 years showed an infection of 95 per cent, with an estimated loss of 19.5 per cent. Moreover, leaf spot was not prevented by treating the seed with copper sulphate or formaldehyde. Negative results were also obtained from sheltering the peanuts before planting. In ordinary outbreaks of leaf spot about 35 per cent of the leaf area is involved by the development of *Cercospora personata*, causing a decrease of 25 per cent in yield. No correlation between temperature and moisture conditions and the prevalence of leaf spot was determined. A study of the habits of 75 species of insects collected in five localities showed that 54 of these species may be concerned in the dissemination of the leaf-spot fungus. Some additional work was also done on citrus canker, the investigation being confined largely to laboratory studies of the organism for the purpose of determining possible means of control.

In a study of the antagonism between salts in soils 17 pairs of salts were quite exhaustively studied. It appears that when two salts, each of which is toxic when employed alone at a given concen-

tration, are presented to the plant in a mixed solution there may be either an increase or a decrease of the toxic effect or in some cases an actual stimulation. The relations between any given pair of salts apparently can not be determined by the employment of a few mixtures in a single concentration, for a single pair of salts may show definite antagonism of the mutual type at one concentration and a complete lack of antagonism at another concentration.

The study of the nature of soil toxins and of the rate of decomposition of certain products of plant origin was continued on four types of soils. All of these soils were found to contain pentose sugars, pentosans, picolin carboxylic acid, cytosin, arginin, histidin, and other decomposition products. Attention was given chiefly to the isolation and identification of the physiologically active organic constituents in soils. Both pyridin and quinolin were found to be toxic in water cultures but not in soil cultures. In the latter they seem to have a stimulating effect.

The study of the fertilizer requirements of soils as shown by analyses of cotton plants was continued in glazed earthenware cylinders supplemented by field tests. Evidence was obtained that the analysis of cotton plants in the four-leaf stage is a safe index of the potash requirements and may also be indicative of the phosphorus requirements. Analyses of cotton plants in later stages of growth gave quite concordant results.

In the investigation of the efficiency of hydrocyanic-acid gas and carbon bisulphid, work was confined largely to the rice weevil. A method of fumigation was devised for the successful treatment of cotton seed in sacks and also for the better diffusion of the gas. The varietal resistance of corn to the rice weevil was studied and some attention was given to the use of trap crops and methods of controlling the rice weevil in storage. About 40 acres of corn are grown for use in the conduct of this investigation. It has been found that varieties of corn with a long husk are quite resistant to injury.

Continuing the project on lead arsenate, various commercial products were compared with the pure arsenate of lead, peach foliage being used as the indicator. An attempt is being made to determine the cause of burning of the foliage. Records are kept of the temperature and humidity of the orchards in which spraying was done. Both powder and paste forms of the arsenates are being used in this work.

The problem of storing Irish potatoes was completed as an Adams fund project. Studies were made of temperature and moisture in relation to storage, and experiments were conducted on forced germination of potatoes for the fall crop. Several treatments, including the use of chemicals, and cutting and scraping the tubers were tested and some of these treatments were found to favor germination.

Considerable shrinkage was noted in the stored crop, some of it being attributed to the action of a small borer.

Work with Hatch and other funds.—The work conducted under the Hatch and local experimental funds was quite extensive. A number of places in the State were selected for the purpose of verifying or modifying results obtained at the main station. About 40 experiments are in progress in different parts of the State. The wheat area of the State has been greatly increased as a result of this work. Most of these experiments had as their ultimate aim the establishment of a satisfactory system of diversified farming, while other experiments were undertaken to learn the best methods of growing cotton. The adaptability of several new varieties of velvet beans was studied and fertilizer experiments with cotton, corn, and other crops were carried on.

The agronomy department conducted its work at the main station and on various farms throughout the State. This work involved a study of alfalfa, clover, vetch, grains, cowpeas, Sudan grass, velvet beans, and various grasses as hay and forage crops. Experiments in soil improvement by means of clover, cowpeas, and velvet beans as rotations were conducted. Some attention was also given to the residual effects of sorghum, soy beans, sweet potatoes, and cowpeas upon the soil. Cultural and variety tests were made with a large number of forage and cereal crops. A series of experiments was begun on the hot-water treatment of the seed of bur clover and sweet clover to hasten germination.

The department of animal husbandry conducted tests of substitutes for milk in calf feeding. Ground velvet beans were compared with cottonseed meal and corn for milch cows, the cows of the two lots receiving an equal amount of silage. Some attention was also given to the effect of different feeds on the character and keeping quality of butter. Data were collected on the cost of keeping cows and the relative economy in the use of home-grown roughage. A successful steer-feeding experiment was carried on with seven lots of steers which were fed different rations, cottonseed meal being an important part of most of the rations. Some experiments in feeding hogs on pasture were also conducted. The value of alfalfa, Johnson grass, and mixed hays was tested in rations for mules. Studies were begun on the production and preservation of eggs.

Under the support of the local experiment fund extensive observations were made on the boll weevil. Practically all but five counties of the State are now infested with the weevil. The life history of the pest is being studied with reference to its adaptability to changed conditions. The fall army worm (*Laphygma frugiperda*) occurs at times in quite disastrous outbreaks. Most of the damage to crops is done during the fifth and sixth larval stages of this pest.

Hibernation takes place in the pupal stage in Alabama. The most effective cultural method of control was found in light, shallow cultivation during the pupal period. Among the arsenical poisons the best results were obtained from arsenate of lead and arsenite of lime.

The horticultural department conducted a wide range of experiments at the main station and throughout the State. The work involved experiments on the control of fire blight on apples, the use of winter sprays on pear orchards, the storage, selection, and cultivation of sweet potatoes, fertilizer experiments with various crops, forcing of tomatoes, and a study of vinifera grapes, Smyrna figs, and truck crops, including cabbage. Some evidence was obtained that the green aphid is associated with the spread of fire blight on apples. A storage house was constructed in which temperature and ventilation may be controlled for studying the keeping qualities of sweet potatoes.

The veterinary department was largely occupied in planning and supervising the new serum plant. Some work was done on the study of poisoning from china berry. Apparently these berries are poisonous to pigs only in the fermented condition. Some attention was also given to osteomalacia in cattle. Evidence was secured that it is largely due to malnutrition in mature animals. Pathological studies were made on organs and tissues of pigs fed cottonseed meal. Some work was also done on various poisonous plants which occur in the State. Much attention was given to tick eradication and to the control of worms and lice which infest hogs.

The following publications were received from this station during the year: Bulletins 185, Dipping Vat for Hogs and Dips—Hog Worms, Lice, and Mange—Hog Lots, Houses, and Water Supply; 186, The Grass Worm or Fall Army Worm; 187, Cabbage; 188, Boll Weevil in Alabama; 189, Wilt Resistant Varieties of Cotton; Circulars 33, Boll-weevil Control by Cotton-stalk Destruction; 34, Annual Report of the Director of the Experiment Station on Work Done Under the Local Experiment Law in 1915; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation, including balance from previous year -----	28,601.06
Farm products -----	613.51
Miscellaneous-----	2,260.06
Total -----	61,474.63

A sharper separation of station and extension work is being brought about. The organization of the station showed improvement

during the year, and the station is in position to conduct its research work in a vigorous manner.

ALASKA.

Alaska Agricultural Experiment Stations, Sitka, Kodiak, Rampart, and Fairbanks.

C. C. GEORGESON, D. Sc., *Agronomist in Charge, Sitka.*

The Alaska stations continued without essential change their work of studying the agricultural possibilities of the Territory and of developing promising lines of farming. The winter of 1915-16 was unusually severe, with continued cold temperatures in the interior of the Territory. Moreover, the growing season of 1916 commenced much later in the spring than during the previous year. The lateness of spring naturally retarded seeding and planting to such an extent that some varieties of grains and vegetables did not reach their normal development until late summer.

At the Sitka station work in hybridizing strawberries and bush fruits was continued. About 1,500 hybrid strawberry seedlings were planted. Several hundred seedling potato plants were also under observation. An increased demand was noted for nursery stock of the station, including apple trees, fruit bushes, rhubarb, horseradish, mint, and other plants. A few of the more promising strawberry hybrids were distributed to a limited extent.

The experimental orchard of apples and cherries bloomed profusely, but the set of fruit was very light. Extremely wet weather caused a considerable percentage of rotting of berries and prevented the development of normal color. Many ornamental plants were procured and tested for their hardiness. The oriental poppy gave very satisfactory results. A large number of varieties of vegetables which had been found unsatisfactory for Alaska were discarded and attention was being given only to the promising sorts. Tarred-paper shields about the stems of cruciferous plants were quite effective in reducing the attacks of root maggots. An arrangement was made with the director of the Tulon Experiment Station, in Siberia, by which an exchange of seeds, particularly of cereals, is made.

At the Kodiak station some difficulty was experienced in providing feed for the herd of cattle in late spring before the grass started. Work on the restoration of pastures and meadows was continued. At the close of the fiscal year several head of Holstein cattle were purchased and added to the station herd. The object of this experiment was to test the Holsteins under Alaskan conditions and to cross them with the Galloway breed for the production of a dual-purpose animal. It was found necessary to be on constant guard against

brown bear, which have become extremely numerous on Kodiak Island and constantly threaten to attack the cattle. The flock of sheep maintained at the station gave a good account of themselves during the year.

At Rampart a period of extremely dry weather hastened the heading of grain, although the straw was unusually short. Winter wheat passed through the winter without suffering much from the severe weather, and winter rye developed an almost perfect stand. No complete success has been had thus far in finding a winter wheat with sufficient hardiness for the Rampart climate. All hardy strains of alfalfa passed the winter successfully and bloomed profusely, giving promise of a good crop of seed. A yellow-flowered variety of alfalfa survived the winter and produced an abundance of seed at the Rampart station in altitude $65^{\circ} 30'$. Many hybrid barleys, oats, and wheats are also under observation.

At the Fairbanks station about 50 acres were seeded to cereals and other crops during the year. One of the main purposes of this station is to secure an increase of seed of varieties which are originated at Rampart. About 200 bushels of selected roots of Petrowski turnips were planted out for seed. Alfalfa varieties suffered more from winterkilling at Fairbanks than at Rampart. Only about 10 per cent of winter wheat survived, while 75 per cent of the rye came through the winter successfully. About 1,200 bushels of grain were thrashed out from the 1915 crop of the Fairbanks station. Most of this grain was distributed among farmers located in the Tanana Valley for cooperative experiments. In this locality more profit has been found from growing cereals for hay than for seed. This practice was quite widely adopted by farmers, with the result that a shortage of seed developed at Fairbanks, leading to the cooperative experiments with the station in which the station furnished seed for further work. This experiment will give opportunity for securing a trial under varied conditions of some of the varieties which have been developed and tested at the station. Nearly 200 farmers are enlisted in the experiment.

The increasing number of settlers in Alaska has made a greater demand upon the stations for seeds and plants. Seeds were sent to more than 2,500 individuals during the year. At the Rampart station alone 96 pounds of Petrowski turnip seed was produced, which will be distributed to farmers. The need of an experiment station in the Matanuska Valley continues to exist. About 800 homesteaders have located claims in that valley and are already at work improving the land. The rapid settling of the region indicates that the possibilities of agriculture are unusually good in this region. The funds available to the stations are insufficient to permit the establishment of the station in the valley.

The following publications were received from this station during the year: Circular 1, Information for Prospective Settlers in Alaska; and the Annual Report for 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation	\$40,000.00
Farm products	1,479.88
Total	41,479.88

The long-continued experiments of the Alaska stations have contributed largely to a knowledge of varieties of cereals, forage plants, garden crops, and ornamentals which are hardy in the Alaskan climate, and the methods for growing them. Moreover, the station has been from the first, and continues to be, a very important factor in the development of farming in the Territory, with particular reference to local food supply for man and domestic animals.

ARIZONA.

Agricultural Experiment Station of the University of Arizona, Tucson.

R. H. FORBES, M. S., *Director.*

Director R. H. Forbes was granted a year's leave of absence for research study and in his absence Prof. G. F. Freeman served as acting director. Prof. J. F. Nicholson, formerly bacteriologist at the Idaho station, was appointed agronomist, and W. E. Bryan, of the Louisiana stations, became assistant plant breeder. By cooperative arrangement with this department Mr. E. W. Hudson, of the Bureau of Plant Industry, will spend a portion of his time in connection with the study of Egyptian cotton in Maricopa County. The new agricultural building was completed and occupied during the year. The building contains, besides the offices of the president and business manager of the university, offices of the director of the station and of the various station departments. Other new buildings erected during the year included a curing house at the Tempe date orchard and new silos at the Prescott and Cochise dry farms. The State appropriation, which will be available to the station during the coming year, is \$31,000.

Adams fund projects.—The underflow studies in the Sulphur Springs Valley were carried forward with satisfactory results. This work was most active in the Casa Grande Valley. An attempt is being made to correlate the fluctuations in the water table with their causes. In this connection the influence of floods and losses through transpiration by plants is being studied. The effect of the operation of pumping plants upon the level of the ground water is also under investigation. Careful attention is being given to the rate and ex-

tent of evaporation. Incidentally it has been found desirable to make a study of the efficiency of pumping plants. As a result of this investigation oil engines are recommended in preference to gasoline engines.

The investigation of feather production in ostriches, while still in the preliminary stage, has resulted in an accumulation of important data and has brought to light more clearly the nature of the problems involved. The ostriches used in the experiment represent different breeding, and the aim of the work is to study closely the feathers of different individuals as to quality and rate of growth. Some work in crossing different breeds will also be carried on. The feed requirements of ostriches have been pretty well worked out, and from now on attention will be given to the effect of different rations upon the production of feathers.

The continuation of the study of factors determining hardiness in the spineless cacti resulted in finding that frost resistance appears to be associated with certain morphological features of cacti, particularly the thickness of the epidermis. Some of this work is carried on under artificially controlled conditions, during which the exact temperature required to destroy the protoplasm is determined. There seems to be an actual difference in the protoplasm of different plants with reference to resistance to frost. It is believed that there is some prospect for the production of hardy hybrids between spineless and native cold-resistant species.

In breeding alfalfa some evidence was produced that strains which appear to be pure in one locality may seem to be mixed when grown under different climatic conditions. An attempt is being made to breed alfalfa for water efficiency with reference to its ability to take up water from the soil and hold it. Incidentally a hairy type of Peruvian alfalfa isolated by breeding during the course of this work has proved to be distinctly more drought resistant than the ordinary type of Peruvian. Not much work was done during the year in the study of tepary beans. Two improved varieties produced by the station were sent out for testing under field conditions, and these varieties are proving to be not only a valuable irrigated crop, but also a reliable crop for dry farming in southern Arizona both for hay and for green manure.

In further breeding work with varieties of sweet corn a considerable quantity of seed was obtained of a new variety of papago sweet corn especially well adapted to extreme climatic conditions. This variety is now being tested on a large scale. In continuing the study of wheat breeding, macaroni wheats were crossed with other wheats in an attempt to secure both quality and hardiness in one variety. The second-generation hybrids of this leading experiment are now under observation.

The study of the toxic effects of copper compounds upon crops was carried on actively during the year. An effort is being put forth to learn the cause of toxicity of copper to plants. The experiments are being carried on by means of water cultures. It appears that the toxic effect of copper is exerted at the growing tips of the roots. Apparently the copper unites with the proteids at the growing points. Under soil conditions the reactions are not so definite as in water cultures. This is explained as indicating that the plant may more readily escape the action of copper in the soil than in water cultures. In very dilute solutions copper was observed to exercise a somewhat stimulating effect with certain species of plants. Corn was found to be very sensitive to copper. Under field conditions it appears that the copper content of irrigating waters contaminated by mines does not exercise decidedly toxic effects upon plants except in rare instances where the copper accumulates in comparatively large amounts.

Work with Hatch and other funds.—The agronomic work of the station is carried on largely at outlying farms (Pl. I), particularly at Snowflake, Prescott, Mesa, Cochise, and Yuma, while at the station farm in Tucson some experiments with alkali soils are in progress. A study is being conducted on the methods and cost of eradicating Johnson grass. The methods under observation in this experiment include continuous dry fallowing, summer fallowing followed by winter grains, winter pasturage followed by intensively cultivated summer crops, and winter pasturing with sheep. Variety testing with various forage and other field crops was continued under dry-farming conditions at Prescott and Cochise.

Perhaps the most important line of work in animal husbandry is sheep breeding. An effort is being made to develop a type of sheep suitable for the conditions which prevail in Salt River Valley. The qualities of different breeds are being combined to get the desired type. For this purpose Hampshire, Tunis, and native sheep are being used. It is believed that a hardy and active type of sheep would prove the most effective and economical means of controlling Johnson grass along ditches and on other lands infested with this grass.

Tepary beans were fed to hogs as an exclusive ration. The animals did not eat the raw beans well and were badly affected by them. Better results were secured by feeding boiled beans. Both at the station farm and some of the dry farms feeding experiments were carried on with dairy cows, using silage as a supplementary feed to grazing upon the range.

In experiments to determine the effect of certain chemicals on plant growth it was found that borax might increase growth to the

extent of 50 per cent. The higher the fertility of the soil the greater the amount of stimulation. Potassium iodid showed no effect on wheat seedlings or water cultures, but in soil it had a marked effect on radishes.

A beginning has been made in a study of soil colloids in relation to slick spots. These spots occur on the station farm and are highly alkaline. Some work is also being done on the hardpan known as caliche underlying the Mesa land. Analyses of the Salton Sea water is now 1:90, showing a considerable increase in the amount of soda.

The botanical work of the station included a continuation of studies of native cacti and of range conditions. A careful study was made particularly of native cacti in the northern part of the State, and the results of these observations are being prepared for publication. In the continuation of range studies it has been found that there is considerable loss of nutritive properties from native grasses. Further work will be done to determine whether there is a loss in the nutritive properties of native grasses after the land is fenced and kept free from stock. Numerous observations were also made on frost resistance in economic plants, such as olives, citrus fruits, and eucalyptus for the purpose of selecting frost-resistant varieties for general planting.

Studies were continued on the date palm, particularly at Tempe. (Pl. II.) Careful records were taken as to the propagation of date offshoots, tolerance of date palms for alkali, and on the control of insect pests and diseases of the date. Other horticultural work included experiments with varieties, fertilization, culture, and methods of harvesting lettuce, a study of methods of cultivating and storing sweet potatoes, and observations on walnut culture in various parts of the State. In this work young native walnut trees have been used as stocks upon which improved varieties are grafted.

The following publications were received from this station during the year: Bulletins 74, Oil Engines for Pump Irrigation and the Cost of Pumping; 75, Papago Sweet Corn, A New Variety; 76, Walnut Culture in Arizona; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation, including balance from previous year -----	39,158.79
Farm products-----	8,842.25
Total -----	78,001.04

Work at the Arizona station during the year was carried on actively and the organization as a whole continues to be effective.

The station is a good example of successful adjustment of investigation to the leading agricultural problems of the State, and the output of high-grade work is very creditable.

ARKANSAS.

Arkansas Agricultural Experiment Station, Fayetteville.

MARTIN NELSON, M. S., *Director.*

The legislature made a generous appropriation for the college and the station, but on account of the shortage of funds in the State treasury many of the items were vetoed by the governor, thus considerably reducing the revenues actually available to the station. Aside from this financial embarrassment the condition of the station was very satisfactory. J. B. Rather, formerly connected with the Texas station, was appointed station chemist. The greenhouse was remodeled, and improvements and additional equipments were made in the chemical laboratory. Moreover, the stock barns were repaired and two silos were erected. Leases were drawn for 80 acres of land to be used for experimental purposes.

Adams fund projects.—Several phases of the project on the relation of hog cholera and swine-plague bacilli to the contagious diseases of hogs were actively prosecuted. Much attention is given to methods for diagnosing hog cholera, standardizing hog-cholera serum, and methods of immunizing hogs by means of serum-free blood cells. In the preparation of an antigen for hog cholera, five strains of virus were used, the inoculated pigs being killed at different stages of the disease. Extracts were prepared from various organs of the body and also from intestinal ulcers. A large series of complement fixation tests was conducted with virus and antiserum but the reaction was negative in all cases. Three methods were used in attenuating serum-free cells—heat, chemicals, and passage through animals, the latter two methods giving somewhat favorable results. Many of the pigs developed cases of chronic cholera as a result of vaccination and were badly stunted after recovery.

The study of inheritance in cotton has been in progress since 1911 and a large mass of records has been accumulated. These data will be compiled for publication in the near future. A study of reciprocal hybrids has been made and comparisons are being instituted between the self-pollinated progeny of the parent varieties. Careful attention is given to correlations.

The effect of methods of harvesting and storing upon the vitality of cotton seed received further study. The purpose of this work is to learn the conditions under which seed cotton and cotton seed can be stored without impairing the vitality of the cotton seed. During the



FIG. 1.—MESA FARM, SHOWING JOHNSON GRASS, ARIZONA STATION.



FIG. 2.—PRESCOTT DRY FARM, ARIZONA STATION.



TEMPE DATE ORCHARD, ARIZONA STATION.

first year of the work it became apparent that damage to seed vitality bore a quite definite relation to the bulk of the seed or seed cotton which was stored. During the year experiments were conducted on a basis of three and five bale lots. It was found that vitality of seed is much reduced under ordinary storage conditions, in some instances to the extent of 50 to 60 per cent.

Encouraging progress was also made in a study of the factors which govern the availability of rock phosphate in acid soils. The purpose of this investigation is to determine the changes in availability which finely ground rock phosphate undergoes when applied to acid soils either well supplied with organic matter or deficient in this material. Pots filled with an acid soil to which lime, manure, and other materials were added in addition to rock phosphate were planted to corn and the growth observed. The amount of available phosphorus is to be determined after two or three crops have been grown in the pots.

In a study of the woolly aphis the station succeeded in establishing the young of the migrants from the elm upon both *Crataegus* and the apple. Parallel experiments are in progress to note the effect of these two host plants upon the biology of the aphis. Fall migrants, reared on *Crataegus*, could not be induced to deposit young either on the apple, *Crataegus*, or the elm. The Northern Spy showed a remarkable degree of immunity to the woolly aphis.

Further work on the round-headed apple-tree borer yielded new data on the habits of the adult beetles. It was learned that the beetles feed upon the fruit as well as upon the leaves and twigs of the apple trees and that in cages females deposit their eggs freely in the fruit and even in small twigs.

The project on pear blight was actively continued. Evidence was obtained that more than one organism may be involved in this disease on the apple tree, five strains in all being isolated from diseased apple twigs. Inoculation experiments with these strains of the organism in different varieties of apples showed one to be particularly virulent for the Yellow Transparent apple. One of the strains which has been obtained from various sources shows different cultural characters from those of the typical pear-blight organism. Much difficulty was met in obtaining the organism supposed to be responsible for the new apple-twig disease. In a series of monthly isolations from diseased tissues about 60 organisms were obtained none of which has been identified with the disease. Special attention is being given to a fungus organism secured from pustules late in winter. Cultural experiments with this organism have thus far failed. Work on peach bacteriosis has been practically brought to a close. The cause of the disease was found to be *Bacterium pruni* and further work

on this subject will be largely in the line of control measures and will probably be supported from other funds.

Xenia in apples was further investigated, particularly with the Ben Davis, Winesap, Jonathan, and Grimes varieties, in an attempt to determine the influence of crossing on the character of the fruit. The season of 1916 was unfavorable and only partly successful fertilization was accomplished in a series of nearly 4,000 pollinations. About 100 fruits were obtained in this experiment and these are being carefully studied. It appears that the size of the fruit may be influenced by cross-pollination but not the color, shape, texture, or flavor. The character of the pistillate parent appears to be dominant over that of the staminate.

In the study of the assimilation of the organic phosphoric-acid compounds in cottonseed meal and in other feeding stuffs for hogs, nine digestion trials were conducted. Particular attention was given to the nature of the organic phosphoric compound in cottonseed meal. It appears to differ materially from phytin or phytic acid. The investigation of the biochemical changes in cotton seed during storage indicated that when cotton seed is ground the fat is rapidly hydrolyzed into fatty acids, about 85 per cent being thus transformed in three weeks. When cotton was gathered dry and stored in the ordinary farm cotton house in lots not greater than 7,500 pounds, no appreciable change in composition occurred. Cotton seed stored in large lots, however, underwent a heating process, causing hydrolysis of the fat.

Magnesium and sulphur in the nutrition of plants was studied with alfalfa, soy beans, and other crops. It was found that with alfalfa sulphates increased the proteins and sulphur, but that pure sulphur was not so active in this respect as sulphates. With soy beans, sulphates increased the sulphur content of the crop but not the total yields. Less pronounced effects were produced on clover. Magnesium chlorid proved to be somewhat toxic.

Work with Hatch and other funds.—The work with the animal-husbandry department was concerned largely with feeding experiments with dairy cows, the use of self-feeders for swine, the study of contagious abortion in cooperation with the veterinary department, and experiments with different breeds of poultry for egg production. In feeding dairy cows, attention was given chiefly to the value of silage and cottonseed hulls in the ration. Feeding experiments with hogs to determine the value of rice by-products were nearly completed. In the treatment of contagious abortion a new chemical preparation was used, but the results from this work are not yet conclusive. In a comparison of various breeds of poultry, attention was given to their relative economy in the use of feed and their egg-laying ability in hot and cold weather.

The entomological department, aside from its Adams fund work, gave particular attention to the peach-tree borer. Various materials were used for protecting trees against this pest, such as asphaltum and white lead. The results were not satisfactory. Asphaltum with a melting point of 115° C., however, gave fairly satisfactory results when mixed with kerosene or other oil. This work is carried on in two localities, one in the southern and the other in the northern part of the State. Similar methods are being applied to the protection of apple trees against the round-headed borer. Some work was also done on methods of fumigating households for the destruction of roaches, flies, ants, fleas, and mice by means of hydrocyanic-acid gas.

The horticultural department devoted its efforts chiefly to potatoes. Some attention is also given to grapes and to variety tests with peaches, cherries, pears, apples, strawberries, and asparagus. About 70 varieties of potatoes are under experiment and the results indicate the possibility of a profitable industry in early potatoes in the Ozark region. In experiments with sweet potatoes it was found that hill selection must be practiced from year to year in order to obtain permanent improvement. The important points in successful storage of sweet potatoes appear to be freedom from disease, careful handling, thorough drying before placing them in storage, and a temperature of 45° to 55° F. in storage.

The general work of the veterinary department involved the study of the immunity of suckling pigs to hog cholera, the curative properties of hog-cholera serums, and a large amount of control work. In experiments with hog-cholera serum it was found that 25 cubic centimeters of serum per 50 pounds live weight, injected within 48 hours after the virus injection, would protect all pigs thus treated. The control work of the department is concerned with anthrax, blackleg, hog cholera, and the eradication of cattle ticks.

The division of plant pathology is conducting a plant disease survey of the State with reference to the economic importance of several diseases. Some experiments were also conducted to determine the effect of the hardness of water on the quality of spraying solution. Thus far the quality of the water has been found to exert little effect on the spraying mixture, particularly in the case of arsenical insecticides. A study is also being conducted on Bordeaux mixture.

The department of agronomy is making a study of acid soils. A survey has already been completed in three counties in which the acidity of the soil has been determined on 800 samples. The other work of the agronomy department consisted largely of cultural experiments with forage crops, tests of annual legumes, variety and cultural tests of wheat, rye, oats, and barley, and a study of the

factors concerned in the winterkilling of oats. Some work was also done in corn breeding.

The following publications were received from this station during the year: Bulletins 124, Sweet-potato Culture in Arkansas; 125, Biochemical Changes in Cotton Seed in Storage; and Circular 28, Fumigating the Household.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation, including balance from previous year	27,416.34
Fees	944.93
Farm products	5,415.49
Miscellaneous	279.02
Total	64,055.78

The Arkansas station is steadily developing its work and gaining fuller appreciation of its efforts throughout the State. The staff has been strengthened by recent appointments, and the prospects for effective work are bright.

CALIFORNIA.

Agricultural Experiment Station of the University of California, *Berkeley*.

T. F. HUNT, D. Agr., D. Sc., *Director*.

All work of the station, whether conducted under Adams, Hatch, or State funds, is planned and carried forward on a project basis. To assist in the administrative supervision of the numerous projects now under way reports at stated intervals are required on each project. The tract of 475 acres of land purchased for the Citrus substation at Riverside is now being made ready. An appropriation of \$125,000 for the erection of buildings became available during the year, and plans for these buildings were decided upon.

At Berkeley another unit of the agricultural building has been planned, for which an appropriation of \$350,000 has been set aside. The new building is to be known as Hilgard Hall. An additional \$25,000 has been allotted for the equipment of this building. Hilgard Hall is to be the headquarters of several divisions of the station and college of agriculture. The college of agriculture as a whole received a State appropriation of \$350,000 for maintenance, about one-fourth of which was devoted to the research work of the station.

Dr. E. W. Hilgard, director of the station from its establishment until his retirement as professor emeritus, died January 8, 1916.

The work on the Adams fund projects is all centered at Berkeley.

None of the Federal fund was spent at Riverside or Whittier, the work there being supported by an annual State appropriation of \$60,000. The Adams fund is expended in the departments of soil bacteriology, veterinary science, plant diseases, and entomology.

Adams fund projects.—Various phases of the project on toxicity of insecticides were actively prosecuted. The work involves a study of the action of constant strengths of hydrocyanic-acid gas on insect eggs, on different scale insects, and a study of gas density in fumigation. It appears that long treatments with a nontoxic dose of the gas increases the percentage of hatching of the eggs of scale insects. Whether an insect can survive treatment depends on its ability to dispose of the poison by forming insoluble compounds. Certain mathematical laws have been worked out with reference to the effect of the gas under different conditions. Thus, in a tight tent, doses of 7, 8, and 9 ounces of cyanid will give the same effects in 60, 45, and 32 minutes, respectively. In certain districts of the citrus belt scale insects seem to become more or less resistant to hydrocyanic-acid gas. In a few localities many of the scale insects survived, although greatly increased dosages were used.

The investigation of tuberculosis involved several phases, including immunization of calves with bovovaccine, intradermal tuberculin tests, prevention of the spread of tuberculosis in cattle and hogs, and cooperative experiments in the control of tuberculosis. The ophthalmic method of applying the tuberculin test was used quite extensively. A combination method involving the use of intradermal, subcutaneous, and ophthalmic methods alternately is regarded as the most reliable. No convincing explanation has yet been found for the prevalence of tuberculosis in range cattle. Apparently the chief cause of the spread of tuberculosis among range stock is to be found in the failure of owners to dispose promptly of animals exhibiting visible symptoms of tuberculosis.

Twelve or more related lines of investigation are grouped together under the project on the study of soil bacteria under arid conditions. Applications of sulphuric acid have been tested with reference to their effect on alkali. The best results were obtained from an application of $2\frac{1}{2}$ tons of acid per acre. Some experiments were also carried on with reference to the effects of the salts of heavy metals upon soil bacteria and plant growth. No injurious effects were noted from the salts of copper, zinc, lead, and iron. A close relationship appears to exist between the nitrifying power of soils and the health of plants in areas on which die-back of citrus trees has occurred seriously. Further progress was also made on the study of the bacteria of soil columns, on the cause of spotted patches in barley fields, and on nitrification as a criterion of the availability of nitrogen in nitrogenous materials.

A comparison of the nitrifying power of soils from the arid and humid regions indicated that this power in the former is no more intense than in the latter and that possibly the nitrifying power of the humid soils is greater than that of arid soils. The most rapid and economical transformation of nitrogen into nitrate was accomplished in the soil flora operating upon low-grade forms of nitrogenous fertilizers rather than high-grade forms like dried blood, tankage, and fish guano. Sulphate of ammonia proved to be the most readily available form of inorganic nitrogen.

The nature of certain physiological plant diseases was further investigated, particularly sugar-beet leaf-curl, and the mosaic disease of tobacco. Curly leaf of the sugar beet is a disease of obscure nature which apparently follows the attack of a minute leaf hopper. The disease has been transmitted to healthy beets by grafting tissue from diseased beets. The disease may be partly controlled by changing the time of planting so as to throw the main period of growth into a cooler part of the year.

Work with Hatch and other funds.—The Hatch fund, aside from that used for administrative purposes, is expended in the departments of agronomy, agricultural chemistry, and animal nutrition. Other lines of work carried on by the station are supported by State funds. At the citrus substation at Riverside extensive experiments were carried on with reference to plant diseases, nitrification of soils, fumigation for scale insects, cover crops, and walnut production. The physiological effects of pruning citrus, walnuts, pears, and apricots are receiving careful attention. Work on plant diseases included a study of gum disease of citrus, scaly bark, apricot rust, citrus rots, and melaxuma of the walnut. A rust disease of apricots has become very serious, defoliating both apricots and peaches. The early attack of the disease can be prevented by delaying pruning in the fall.

A study of nitrification in the soil of citrus orchards indicates that there is no connection between nitrates and mottled leaf of citrus. In fertilizer experiments the plats which received nitrate of soda became impervious to water as a result of deflocculation. A study of the movement of nitrates in the soil indicated that the soluble material under irrigation diffuses laterally instead of going down, so that nitrates and other soluble salts accumulate between the furrows and are not extensively carried down to the roots of growing trees.

At Whittier studies are being conducted on the penetration of irrigation water, losses through evaporation, and run-off in orchards. It is believed that the bad effects noted from furrow irrigation may possibly be overcome by the use of overhead irrigation. The English walnut is also being studied with reference to the relation between varieties and blight. It has been found that the trees which put out their leaves earliest are the best producers.

The work of the station carried on at other localities in the State is under the more direct supervision of heads of departments at Berkeley. The horticultural experiments during the year included a study of pollination in plums, the production of almonds, systems of training and pruning orchard trees, a study of planting distances for deciduous orchard trees, and the cultural requirements of pecans. It has been found that all varieties of Japanese plums are self-sterile with possibly one exception. Cross-pollination, however, is readily accomplished between these varieties. French and sugar prunes seem to be self-sterile to some extent. The setting of fruit on the French prune exposed to normal conditions was about 4 per cent as compared with about 19 per cent on a tree covered with mosquito netting under which bees were maintained. Evidence was also obtained that the leading commercial varieties of cherries are self-sterile.

The work on plant diseases included spraying experiments for pear scab, a study of asparagus rust, peach blight, pear blight, brown rot of citrus fruits, cottony rot of lemons, and spotting of citrus fruits from the action of oil liberated from the rind. Thorough spraying with Bordeaux mixture in late November and again just before the blossoms opened with Bordeaux or lime-sulphur solution gave almost perfect control of peach blight. Asparagus rust was checked by dusting with sulphur. Pear scab was held in control by two sprayings with Bordeaux mixture. The cottony rot of lemons was shown by inoculation experiments to be due to a species of *Sclerotinia*. The most satisfactory method of control was found in the use of a wash water containing one-fiftieth per cent of copper sulphate. The walnut disease known as melaxuma proved to be due to *Dothiorella gregaria*. The disease may be controlled by cutting out the cankered spots and disinfecting the cuts. The spotting of citrus fruits as a result of oil exudation on the skin occurs most frequently when the fruit is picked in rainy weather. Extreme care in handling and picking the fruit only when dry have resulted in obviating most of this trouble.

The entomological work of the station involved a number of experiments, particularly with fumigation and other insecticides and methods of calibrating leakage and of standardizing dosage tables for hydrocyanic-acid gas. It was shown that cresols are more active as fungicides than is phenol, and that the higher boiling cresols, especially metacresol, are more active than the lower boiling cresols. Commercial cresol appears to be usually a mixture of the three cresols. An examination of crude phenols showed a very unsatisfactory condition among the commercial samples offered on the market. A study of the mealy bugs of citrus trees showed that there were four species commonly found upon citrus trees in the southern

part of the State. *Pseudococcus citri* is by far the most important of these species. For the control of mealy bugs fumigation with hydrocyanic-acid gas is not recommended. Good results are obtained, however, from spraying with water under high pressure. Work is also under way in the study of the effect of humidity on the life history of granary insects, the effect of cyanid on bees, and on the control of wild morning-glory by arsenical sprays. A study of alfalfa insects is also being carried on at Davis.

In the department of genetics the study of walnut-oak hybrids was continued. Some breeding experiments with lilies and also with peaches were carried on. In a continuation of the study of tobacco hybrids, 75,000 flowers of hybrids obtained from a certain cross were measured. The factors of inheritance in several wild species of strawberries are also under study.

Among the problems investigated by the veterinary department were chicken pox, white diarrhea, and other diseases of poultry, as well as hog cholera, diarrhea in calves, lymphangitis in cattle, and barrenness in cattle as a possible result of feeding alfalfa. A statistical field survey has been made in counties where alfalfa is used extensively, but no direct evidence was obtained that alfalfa causes abortion or sterility. About 50,000 fowls were vaccinated for chicken pox in a further test of this method for controlling the disease. A large mass of data has been accumulated on the results obtained in the use of hog-cholera serum.

A large number of experiments supported by State funds were carried on with reference to the culture of grapes and olives. In the San Joaquin Valley the work related largely to resistant stocks and raisin grapes. The possibilities of bud selection for the improvement of the grape are under investigation. Variety tests of grapes were also conducted in the Imperial Valley, where experiments were carried on in making unfermented grape juice. Work was also done in devising methods for better preserving the flavor of grape juice, for making jellies from citrus fruits, and for home canning of fruits under the use of a low temperature. A large amount of work was also done on methods of growing and grafting olive seedlings.

A survey of citriculture is being carried on in the northern portion of the State. Avocado seedlings of known parentage are under investigation in the Imperial Valley. Further attention is being devoted to the study of the fig industry, the Japanese persimmons, and other subtropical fruits.

The agronomy work of the station is carried on at Davis, Kearney Park, El Centro, and Stockton. The factors of pollination of corn are under investigation. It has been found that the pollination of corn is often deficient in California. This work has involved test-

ing of corn varieties, including several from Bolivia. Variety experiments are also in progress with sorghums, milo maize, feterita, potatoes, beans, and cotton. Both cultural and breeding methods are being studied in the case of cotton, especially with Durango and Egyptian varieties.

In the field of animal nutrition, feeding and metabolism experiments have been begun with day-old chicks, using purified food materials. An attempt is being made to determine the materials which will supply the essentials of growth. Experiments have also been conducted in feeding oil meal as a part of the grain mixture for skim-milk calves. In a test of the value of spineless cactus for cows it was found that cows did not readily eat this material. In feeding experiments with pigs it appeared that raisins gave good results when fed with alfalfa meal and barley, but were not profitable unless very low in price.

Feeding experiments with dairy cows indicated that barley had a tendency to increase the milk flow over that obtained by the use of grain rations not containing barley. An experiment is also under way in which dairy heifers and cows will be fed on alfalfa as a sole ration. Some data were accumulated on the cost of producing goat milk. The records of the official tests of pure-bred dairy cows have been compiled to serve as a basis of a study of the inheritance of milk yield.

Experiments in the drainage of alkali land are being carried on in cooperation with this department on an area of 160 acres of highly alkaline soil. The irrigation experiments of the station are also conducted in cooperation with this department. Data are being collected on the duty of water and the effect of applying different depths of water to alfalfa and other crops.

The following publications were received from this station during the year: Bulletins 255, The Citricola Scale; 256, The Value of Barley for Cows Fed Alfalfa; 257, New Dosage Tables, Fumigation Studies No. 7; 258, Mealy Bugs of Citrus Trees; 259, Commercial Fertilizers; 260, The Determination of Availability of Nitrogenous Fertilizers in Various California Soil Types by Their Nitrifiability; 261, Melaxuma of the Walnut, *Juglans regia*; 262, Citrus Diseases of Florida and Cuba Compared with Those of California; 263, Size Grades for Ripe Olives; 264, The Calibration of the Leakage Meter, Fumigation Studies No. 8; 265, Cottony Rot of Lemons in California; 266, A Spotting of Citrus Fruits Due to the Action of Oil Liberated from the Rind; 267, Experiments with Stocks for Citrus; 268, Growing and Grafting Olive Seedlings, I and II; 269, Phenolic Insecticides and Fungicides; Circulars 130, Cabbage Growing in California; 131, Spraying for the Control of the Walnut Aphid; 132, When to Vaccinate Against Hog Cholera; 133, The County Farm

Adviser; 134, Control of Raisin Insects; 135, Official Tests of Dairy Cows; 136, *Melilotus indica* as a Green-manure Crop in Southern California; 137, Wood Decay in Orchard Trees; 138, The Silo in California Agriculture; 139, The Generation of Hydrocyanic-acid Gas in Fumigation by Portable Machines; 140, The Practical Application of Improved Methods of Fermentation in California Wineries During 1913 and 1914; 141, Standard Insecticides and Fungicides v. Secret Preparations; 142, Practical and Inexpensive Poultry Appliances; 143, Control of Grasshoppers in Imperial Valley; 144, Oidium or Powdery Mildew of the Vine; 145, Suggestions to Poultrymen Concerning Chicken Pox; 146, Jellies and Marmalades from Citrus Fruits; 147, Tomato Growing in California; 148, Lungworms—A Preliminary Report on Treatment, with some Observations Regarding the Epidemiology and Life History of the Parasite; 149, Lawn Making in California; 150, Round Worms in Poultry—Life History and Control; 151, Feeding and Management of Hogs; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	95,777.23
Fees, including balance from previous year	9,494.76
Sales, including balance from previous year	40,182.74
Miscellaneous	27,949.35
Total	203,404.08

The California station is carrying on an exceedingly large and varied amount of work bearing upon the various types of agriculture in different parts of the State. A satisfactory institution for the study of problems connected with subtropical agriculture is being developed at Riverside. The station has not yet fully solved the problem of protecting its research men against the increasing calls for extension and teaching work.

COLORADO.

Agricultural Experiment Station, Fort Collins.

C. P. GILLETTE, M. S., Director.

A one-fourth mill tax was granted by the State to the State board of agriculture for the use of the station. The State funds thus rendered available to the station amount to from \$26,000 to \$28,000 a year. At Rocky Ford an alfalfa substation is maintained, a dry-farm substation at Cheyenne Wells, and a substation for high-altitude agriculture at Fort Lewis. The area used at the station for experimental work is about 60 acres, while about 500 acres additional are maintained for pasture tests in connection with the horse-breeding

work. In the allotment of funds and the assignment of men about equal emphasis is placed on irrigation, chemistry of soils, and wheat and general agronomy. During the coming year it is planned to spend about \$7,000 of State funds in irrigation and drainage investigations and about \$6,000 in feeding experiments with steers. A central heating plant has been authorized under a State appropriation of \$50,000 and construction of the building has already begun.

Adams fund projects.—The investigation of plant lice was continued with special reference to the life history and food habits of these insects. The work is understood as including a study of all species of aphis, but particular attention has been laid on woolly aphis, green apple aphis, black peach aphis, *A. bakeri*, and *A. avenae*. The life history of all these species has been worked out quite thoroughly. During the course of the work it has been found that injurious species of aphis so commonly infest weeds as host plants that all species of aphis must be brought under study as to their possible connection with alternate stages of injurious species. *A. bakeri* lives on the apple and crab in winter, while in the summer it attacks clover. This aphis caused an unusual amount of injury to clover in parts of Colorado and near Gooding, Idaho, during 1916.

Satisfactory progress was made in the study of the drainage requirements of crops. The data obtained during four years' investigation are now ready for analysis. By means of a series of concrete tanks the ground level of the water was maintained at constant depths of 2, 3, 4, 5, and 6 feet. One series of these tanks contains alkali, while the second contains normal soil, half of each series being cropped with alfalfa and the other half with sugar beets. Alfalfa showed a slight difference of growth under these varying conditions, the results obtained being somewhat in favor of the 6-foot water level.

In the further investigation of weir construction it was found that the average ratio of the cross-sectional area of the weir box to that of the notch required to give discharges within 1 per cent of the values obtained with the formula is greater than 7 and is probably nearer 15. For all practical purposes discharges through rectangular and Cipolletti notches are not affected until the notch is submerged to a depth equal to one-tenth the head upstream from the weir. A new irrigation weir was constructed having the advantages of being self-cleaning and of not requiring the lowering of the canal grade or the building up of the banks. Its accuracy was found to be consistent and constant. The weir is not patented and the cost is, therefore, merely that of materials and labor.

A study of conditions which affect the operation and accuracy of current meters was continued. About 14 types of current meters were used, all being tested under varying conditions of position and

support. This work involved 377 tests and resulted in the accumulation of a large mass of data. The idea underlying this work is to secure means of standardizing the rating of meters. An attempt is being made to find compensating factors for use in tests of meters under different conditions and to determine the absolute accuracy and the variation of meter readings from the actual rate of flow.

The further study of the factors causing the softening of wheat brought out some interesting results. The investigation of wheats has been nearly completed and attention will now be given to flours. Nitric nitrogen has been carefully studied in relation to the composition of the wheat kernel. It has been shown that water has little to do with the composition of the grain. Nitrogen, however, in any other than the nitric form appears to have no effect on the quality of the wheat grain, although it may increase the yield. No effect upon the composition of wheat was produced by varying irrigation water from 6 to 36 inches, while the addition of nitric nitrogen to the soil, even to the extent of 40 parts per million, increased the total nitrogen in wheat. It was found that flinty wheat is developed on soils containing an abundance of nitric nitrogen, while starchy wheat is produced when potash is added to the soil.

The application of sodium nitrate increased the total amount of ash, while the use of phosphorus and potassium seemed uniformly to lower the amount of phosphorus in the plant. The amount of potash in the plant, however, was not influenced by the application of either phosphorus or potash.

Further work was done on the fixation of nitrogen in Colorado soils with particular reference to so-called niter spots. The development of niter spots in the San Luis Valley and elsewhere has become a serious matter. An attempt will be made to determine whether cretaceous or other shales carry nitrogen to an appreciable extent. Nitrates have accumulated in some of these soils to an extent which prevents the growth of crops. The conditions found in Colorado in this regard are quite similar to those which prevail in certain areas in Montana.

The investigation of the Rio Grande River water in the San Luis Valley indicates that while the soils contain a high percentage of carbonates the river does not drain the valley and, therefore, does not take up any large quantity of alkali salts in passing through the valley. The soils contain humus to a depth of 800 feet or more, sufficient to give a brown color to the artesian waters. These waters contain from 22 to 108 grains of sodium carbonate per gallon.

The results obtained from the further study of alkali soils in relation to nitrogen fixation were of much interest. Preliminary tests of virgin soils showed no protozoa to be present and only two species of Paramecium were found in cultivated soils. The number of protozoa

in soils throughout the State is extremely low. It is suspected that possibly alkali may prevent the growth and multiplication of protozoa. For purposes of comparison samples of soils were obtained from various eastern States. It was found that nitrification in Colorado soils was six hundred times more active than in any of the eastern soils. Essentially the same condition was found for ammonification. Incidentally, some attention was given to radioactive fertilizers in relation to nitrification. Certain soils and waters in Colorado have been found to be radioactive.

The project on the bacterial disease in the field pea was practically completed during the year except for some variety tests with reference to the immunity of different strains of field peas. It was found that the bacterial stem blight of field and garden peas occurs generally over the San Luis Valley and northern Colorado. The disease is characterized by the watery, olive-green color of the stems and by the yellowish stipules and leaflets. The blight is caused by *Pseudomonas pisi*, a new species of bacterial organism which enters the tissue through the stomata and through wounds. The only satisfactory control of the disease appears to be through the use of resistant varieties.

Work with Hatch and other funds.—The agronomy section devoted much attention to the statistical study of correlation in breeding oats, wheat, and barley. The object of this study is to learn whether the same correlations prevail in hybrids as in the parent form. Many points of weakness were found in statistical methods. For example, it was learned that the index of correlation varies according to the plan of grouping the data for comparison. In barley 5 pairs of characters are under study with 30 or more possibilities of association. During the year it was found that the two-rowed character, the hooded character, and black color are dominant. In F_1 hybrids a two-rowed, hooded, black barley was obtained which splits up into several characters in subsequent generations. Irrigation experiments were conducted for the purpose of following the correlations obtained under irrigated and nonirrigated conditions. It appears that withholding water shortens the straw and that one application of water may hasten the maturity without producing any change in the correlation. At Rocky Ford breeding experiments are in progress with alfalfa for seed production. The Grimm alfalfa has been found to thrive well at an elevation of 9,000 feet. Water was found to be an important factor in alfalfa-seed production. The study of the growth and behavior of crops at an altitude of 8,000 feet is conducted at Fort Lewis, where about 20 varieties of peas and also alsike clover, small grains, and corn are under observation. A yield of 8 tons of corn silage per acre has been obtained at this elevation. Farm-

management surveys are being carried on particularly in dry-farming regions.

The section of plant pathology devoted particular attention to a bacterial disease of cherries. The disease appears to be confined to the Wragg varieties, affecting the fruit, leaves, and twigs. An organism has been isolated which is apparently *Bacterium pruni*. Infection was readily produced by spraying the fruit with pure cultures of the organism. Lime-sulphur gave no benefit during the dormant period but was quite effective when applied at frequent intervals during the growing season.

The botanical section obtained some interesting results in a study of millet smut. Two species of smut are concerned, *Ustilago crameri* on Italian millets and *U. panici miliacei* on proso millets. Millet seedlings were grown in the laboratory and inoculated with spores in the seeds and in the vegetative parts. No infection was produced during the winter. In the spring, however, infection was easily brought about. It was found that *U. crameri* causes smut in all Italian millets but did not infect any of the proso millets, while *U. panici miliacei* infected all of the proso millets but none of the Italian millets. Formalin proved to be a complete protection against smut infection. A study was also made of native vegetation as an index of crop possibilities at altitudes of 7,000 to 8,000 feet. This study involved about 3,000 miles of travel and resulted in the determination of certain native plants as a safe index of the possibilities of crop production. Some attention was also given by the botanical section to a general study of fungus diseases of Colorado plants.

The irrigation section devoted much attention to a general study of conditions in the Poudre River Valley. During the coming year the main efforts of the irrigation section will be devoted to this study. The work includes an investigation of the efficiency of reservoirs, duty of water, variations in canal practice, and data on crop production, on a number of farms which have been specially chosen for the purpose. The work will also involve a study of water rights, the temperature of irrigation water and of soils. The area covered by this investigation is about 400 square miles. Some attention has also been devoted to a mathematical study of the statute inch or miner's inch, in connection with water measurement and to the use of irrigation water in the San Luis Valley.

The horticultural section devoted its energies largely to a study of hardy stock for apples, pear growing in eastern Colorado, management of niter soils in orchards, potato investigations, and a study of seed-potato growing, hardy trees, and small fruits for high altitudes. In studying the effect of ridges on soil temperature in potato fields

it was found that the temperature was much higher in ridges or hills than in the soil. When potatoes are grown in flat culture the irrigation water becomes heated and the potatoes mature too rapidly. Experiments were begun in lowering the ridges so as to prolong the period of maturity, and good results have followed the use of ridges 8 to 10 inches high instead of the usual 18-inch ridge of the Greeley potato growers. Under the common commercial practices the potatoes have a too high content of water. High soil temperature and poor aeration appear to be the chief adverse factors in potato production in Greeley. Near Grand Junction an area of niter soil was selected for experiment. This area was of a black color and absolutely barren. This was partly reclaimed by flooding for two months by means of a system of dikes and flowing water. A fruit survey of the Grand Valley was conducted, involving an area of 15,000 acres.

The general work of the entomological section involved, besides the usual details of nursery and orchard inspection, a study of codling moth, grasshoppers, and miscellaneous insect pests. Excellent success was had in controlling grasshoppers by the use of bran mash poisoned with Paris green. Considerable work was done on the life habits of syrphus flies, with particular reference to the relation of these insects to plant lice. A large mass of data was accumulated on the habits and life history of the codling moth in the Grand Valley. Experiments were also conducted with a variety of insecticides for the control of common insect pests.

The veterinary section continued its observations on brisket disease, particularly on the pathological aspects of the disease. Some work was also done on sore mouth, infectious anemia, sheep losses during the winter, and poisonous plants.

The horse investigations in cooperation with this department were continued without change and with highly satisfactory results. Considerable work was also done in analyzing data obtained in feeding experiments during the previous year. The forestry section conducted some studies on the decay of wood and on methods for eradicating dandelions.

The following publications were received from this station during the year: Bulletins 206, Spur Blight of the Red Raspberry Caused by *Sphaerella rubina*; 207, The Colorado Statute Inch and Some Miner's Inch Measuring Devices; 208, A Study of Colorado Wheat; 209, Irrigated Agriculture in the San Luis Valley; 210, Insects and Insecticides; 211, Colorado Plants Injurious to Live Stock; 212, Fungus Diseases of Colorado Crop Plants; 213 Poultry Raising in Colorado; 214, Forage Crops for the Colorado Plains; 215, The Dethridge Meter; and 216, Studies of Health in Potatoes.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	19,868.00
Farm products, including balance from previous year	656.92
Miscellaneous, including balance from previous year	16,565.61
Total	67,090.53

The scientific work of the Colorado station continues to yield results of practical importance and of large scientific value. The relations of the different sections of the station to one another are cordial and helpful, and the farmers and other citizens of the State appear to be thoroughly in sympathy with the work of the station. It therefore is in position to contribute largely to the development of the State.

CONNECTICUT.

The Connecticut Agricultural Experiment Station, New Haven.

E. H. JENKINS, Ph. D., *Director.*

The active lines of work at the Connecticut State station were the same as in the previous year. No new enterprises were undertaken and no extensive additions to equipment were made. The greenhouse was rebuilt and a small insectary was constructed. The research work of the station is largely confined to the projects on plant breeding and on the nature of protein. The corn survey, involving tests of individual varieties, was continued in cooperation with the Storrs station.

Adams fund projects.—Breeding work with dent, flint, and sweet corn was continued with encouraging results. Studies on the inheritance of the chemical constituents of corn have been under way for two years. Among 12 first-generation crosses between commercial varieties of corn 7 yielded more than the better parent. More than 250 first-generation crosses between strains of corn previously inbred for 9 generations are under observation. Some breeding work was also done on tobacco and tomatoes, particularly the selection of tobacco from crosses between Sumatra with Broadleaf and Cuban with Havana.

With regard to the inheritance of the starch character in corn, data were obtained indicating that two independently inherited factors are necessary for the production of a strongly pointed seed. The characteristic point of the rice popcorn may be transferred to dented seeds by crossing and selection, the inheritance of these char-

acters being entirely independent of each other. A study of the amount of corneous and floury starch in hybrid corns showed a wide variation in the second generation. Thus far it has been impossible to determine how many factors are involved in producing these differences, but apparently types are readily recovered and breed true.

Decided and important progress was made in the study of the composition, constitution, and properties of proteid bodies and their relative efficiency in nutrition. Experiments with feeding stuffs high in protein have been nearly completed and also the experiments to determine the minimum quantities of different proteins required for growth or maintenance. It appears that with approximately equal intake of feed essentially equal gains of weight were made by rats receiving in their food 8 per cent of lactalbumin, 12 per cent of casein, and 15 per cent of edestin, respectively. In feeding experiments with young rats, foods containing lactalbumin in every case produced the greatest gains. In order to produce the same gain in body weight 50 per cent more casein and 90 per cent more edestin were required than of lactalbumin.

Observations were also made on the resumption of growth after long continued failure to grow. It appears that prompt response is commonly made to the opportunity to complete growth and that even when the stunting is continued for long periods from an early age the capacity to resume growth adequately is retained. It was quite definitely shown that the need for tryptophane and lysin is governed by the law of minimum, the rate of growth increasing with increasing amounts of these amino acids until the normal rate is attained. Further study on the growth promoting substance in butter fat indicated that this body possesses a high degree of stability under ordinary conditions of storage.

A series of experiments was undertaken to learn more about the anaphylactic reactions between proteids from different plants. The results indicate that chemically similar proteins from seeds of different genera react anaphylactically with each other while chemically dissimilar proteins from the same seed in many cases failed to do so. It is concluded, therefore, that the specificity of anaphylaxis depends upon the chemical nature of the protein molecule. In the work with proteid feeding stuffs no evidence of toxicity was observed in feeding cottonseed meal. The conclusions of the Wisconsin station that there are at least two accessory food bodies, one soluble in fat and the other in water, were strongly substantiated. A careful study has also been begun of the constituents of milk in the light of recent research in nutrition.

Work with Hatch and other funds.—The general work of the department of plant breeding involved a corn survey of the State and

selection work with soy beans and rye. In the corn survey 75 varieties of corn are grown at the station and also at the Storrs station, in trial plats, to determine their relative yield and their behavior under different climatic conditions. Some promising selections of soy beans and rye were made.

The botanical department devoted its efforts chiefly to a study of peach yellows, powdery scab of potatoes, tobacco diseases, and the white-pine blister rust. With peach yellows an attempt is being made to determine all possible avenues of infection and also the effect of fertilizers on prevention or retardation of the disease. Work thus far conducted on the powdery scab indicates that under normal conditions at the station neither the land nor the crop is infected by the use of infected seed. The calico disease of tobacco was carefully investigated. This appears to be a disease primarily of the chlorophyll. It is infectious and may be communicated by mere contact of diseased plants or by the juice from diseased plants on the hands of workmen. Control of the disease was best brought about by annual steam sterilization of the seed bed and occasional sterilization of the hands with soap and water during the process of transplanting.

The entomological department is occupied to a considerable extent with nursery inspection and insect control. During the year the department inspected 86 nurseries, more than 2,000 packages of imported nursery stock, and 467 apiaries. Inspection work included a survey of the area infested by the gypsy moth. The life history and habits of an imported pine sawfly were carefully studied and five species of parasites were reared from them. About 2,700 acres of salt marsh were ditched and otherwise treated during the year in the work of mosquito extermination required by law. Work was also done on the habits, life history, and method of control of cabbage maggot, larch sawfly, white-pine weevil, mealy bugs, scale insects, white grubs, and other injurious insect pests.

The department of vegetable growing succeeded in producing a promising hybrid sweet corn and this hybrid will be kept under further observation. It is commended for its size, earliness, and sweetness. An extensive experiment was also undertaken to learn the effect of time of sowing and methods of growing seedling tomatoes upon the earliness and yield of fruit. Considerable attention was also given to cultural methods of growing various other market garden crops and to means of protecting them against disease.

The work of the chemical department was largely concerned with the control of fertilizers and feeding stuffs as required by law, with the analysis of human food products and drugs, and with testing dairy apparatus. The department also cooperated with other departments of the station in analyzing soils and samples of vegetable material.

The forestry department conducted experiments in the partial sterilization of forest seed beds with formalin and sulphuric acid, carried on work with willows, hybrid catalpas, and made a forest survey. The work of this department also included the preparation of a report on forest fires for the year.

The following publications were received from this station during the year: Bulletin 187, Index to Reports on Food Products and Drugs, 1896-1914; 188, Further Experiments on Inheritance in Maize; 189, A Mosquito Survey at the Mouth of the Connecticut River; 190, Insects Attacking Cabbage and Allied Crops in Connecticut; 191, Tests of Soy Beans, 1915; the Annual Report for 1914, part 6; and the Annual Report for 1915, parts 1 to 5.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$7, 500. 00
United States appropriation, Adams Act	7, 500. 00
State appropriation	24, 000. 00
Individuals	11, 374. 31
Fees, including balance from previous year	9, 855. 22
Farm products	46. 92
Miscellaneous	729. 34
 Total	 61, 005. 79

The Connecticut State station, in its investigation of protein feeding stuffs and their relative efficiency in nutrition, is making important scientific contributions to the knowledge of this subject. The large amount of practical work which the station is doing brings the members of the staff into quite intimate contact with the most urgent agricultural problems and makes it an efficient and useful agency.

Storrs Agricultural Experiment Station, Storrs.

E. H. JENKINS, Ph. D., *Director.*

Some curtailment of the work of the station was considered necessary on account of lack of funds. Effort will be made to secure more adequate provision by the State legislature for the work of the station. There was no change of policy during the year. At the close of the year W. M. Esten, bacteriologist, was transferred to college work.

Adams fund projects.—Further progress was made in the study of white diarrhea in chickens. With regard to the influence of the male in the transmission of this disease no positive results were obtained. In 1,037 males only 2.1 per cent were infected, while 9.8 per cent of the females in a total of more than 22,000 reacted to the test. Some attention was also given to the relationship of bacillary diarrhea to fowl typhoid. It appears that the organisms of these two

diseases closely resemble one another but are not identical. No definite results were obtained from the study of the toxicity of *Bacterium pullorum* when fed to animals.

The investigation of blackhead of turkeys was actively continued, but no results of a decisive nature were obtained. Experiments in poultry feeding thus far conducted have not resulted in finding a simple ration which is as efficient as the standard rations commonly recommended. The egg-laying contest, however, was conducted with a much simpler ration than heretofore and the average egg production was 162 per hen as compared with 152 for the previous year. Additional growth curves for Leghorns and Rhode Island Red fowls were secured.

The study of the effect of subnormal temperatures during the incubation of eggs was continued as heretofore. The data obtained during the year have not been tabulated, but it appears that embryos of various ages will endure exposure to a temperature of 10° C. Work on breeding for egg production has been continued for three years and records have been obtained on about 100 hens. Plans were made to continue the investigation on more than 200 Leghorn hens during the coming season.

The project on contagious abortion was actively begun under support of Adams funds. For two years previously animals of all ages had been tested and a large mass of data relating to the disease had been accumulated. Evidence was obtained that calves from reacting mothers are themselves reactors at birth, but invariably become nonreactors within from three to five months. They do not become reactors for some time even when exposed to the disease. These animals will be kept under observation until after the first calving season.

Work with Hatch and other funds.—The general work of the poultry department was largely confined to a study of the external parasites of poultry and to conducting the third annual international egg-laying contest. The life history, habits, and means of controlling a number of insect pests of poultry, chiefly lice and mites, were investigated. In the third annual international egg-laying contest it was found that the cost of feed to produce a dozen eggs was 16.1 cents for Plymouth Rocks, 14.3 cents for Wyandottes, 15.8 cents for Rhode Island Reds, and 12.4 cents for Leghorns. The returns above cost of feed for the various pens of fowls ranged from \$15.12 to \$24.37. Considerable attention was also given to methods of constructing poultry houses and to the principles of constructing brooder houses, trap nests, and dry-mash hopper.

The work of the agronomy department included the study of crop rotations, variety tests with corn, cereals, soy beans, and root crops, hill selection and storage of potatoes, the potash requirement of po-

tatoes, cultural requirements and varieties of alfalfa, and the production of corn in combination with soy beans for silage.

The dairy department of the station conducted a comparative test of various methods of making the Babcock fat determination to determine how far differences in detail of manipulation may influence the result. A study of dairy-herd records was continued. The questions under consideration in this work are seasonal influence and the effect of breed and individuality on butter fat. Some calf feeding experiments were also conducted to test the value of silage. Observations were made on the capacity of silos.

The bacteriological department conducted investigations on Camembert cheese, commercial lactic starters, various kinds of litmus for bacteriological work, and on the bacterial content of ice cream. It was found that by transferring milk cultures of *Bacterium lactis acidi* daily the activity of the bacteria is increased. Strains which are not sufficiently active after a fourth or fifth transfer are believed to be of doubtful value. Laboratory experiments indicated that the media best adapted for the long keeping of this class of lactic organisms are milk with calcium carbonate added and standard bouillon containing 1 per cent of saccharose. When ice cream was kept frozen for a month or longer no marked increase or decrease in the bacterial content was observed. Some improvements were made in an electric incubator for bacteriological work.

The following publications were received from this station during the year: Bulletins 81, Poultry House Construction; 82, Third Annual International Egg Laying Contest; 83, Bacteriological Studies; 84, An Electric Incubator for Bacteriological Work; 85, Bacillary White Diarrhea of Young Chicks, V; and 86, Some Lice and Mites of the Hen.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$7,500.00
United States appropriation, Adams Act	7,500.00
State appropriation	4,500.00
Miscellaneous, including balance from previous year	9,782.71
Total	29,282.71

The research work of the Storrs station is especially strong in poultry husbandry, particularly in the investigation of white diarrhea, methods of feeding poultry, and breeding for egg production. The work of the station could be profitably extended by the provision of State funds. The two stations in the State have their work so adjusted as to avoid duplication, and in effect are largely managed as a single station.

DELAWARE.

The Delaware College Agricultural Experiment Station, Newark.

H. HAYWARD, M. S. Agr., *Director.*

The construction of a new agricultural building to be known as Wolf Hall was begun, which is expected to be ready for occupancy in the fall of 1917. It will cost about \$280,000. At the close of the year W. A. Lintner, assistant agronomist, resigned and his place was filled by the appointment of M. L. Nichols. F. B. Hills was succeeded by M. F. Grimes as assistant in animal husbandry. J. J. Taubenhaus resigned his position and J. A. Elliott was appointed to the position thus made vacant. The agricultural department has become a prominent feature of the college, and this development is reflected to some extent in the growth of the station.

Adams fund projects.—The study of the differences in the extent to which different types of wheat respond to various kinds and quantities of plant food was continued with two varieties of wheat. A reduction was made in the number of varieties used during the previous year and in the area of field plats in order that the chemical work involved in this project might be brought up to date. Thus far five years' results, including complete analyses of grain and straw, have been secured. Indications have been obtained that certain differences exist in the capacity of different varieties to take up phosphorus, potassium, and calcium.

The effect of lime on the decomposition of organic matter in soils was studied under laboratory conditions. In this work samples of soil are maintained under bell jars and aerated under currents of air drawn through. No crop is grown on the soils. Analyses are made every three months. The organic matter was derived from green plants, chiefly crimson clover. Some interesting results have been noted in the effect of various forms of lime upon solubility of phosphorus and potash.

Further work was done on the effect of variations in physical and chemical character of the corn kernel upon the vigor of the plant. The field work was temporarily discontinued during the year. Considerable variation in the yield of the crop has been noted from seed of varying physical characters. The most marked results were obtained when kernels of certain types were planted during cold and unfavorable weather.

The chemical composition of fruits under normal and abnormal conditions received considerable attention. A special effort was made to devise a method for determining the different organic acids when occurring in association. No success has been had in attempting to determine them by polarimetric methods. Attention is being given to

the hydrogen ion concentration of fruit juices at all stages in the development of the fruit. Some work was also done on the pectins of apple juice.

Work on the functions of nitrogen, potash, and phosphoric acid in apple and peach production was continued. The peach trees have come into bearing and the fruit is under study. The fruit and pits are analyzed, and measurements are kept of the prunings and of the fallen leaves. No connection was noted between pruning and the vigor of growth. From time to time records are made of drainage waters. Nitrogen appears to be of prime importance in the nutrition of the peach, and evidence has been obtained that growth can be checked by the use of excessive amounts of phosphoric acid. The introduction of more intimate physiological studies would strengthen this work from now on.

The effect of in-and-in breeding of dairy cattle and swine was studied, particularly on swine. In this work 17 cows are being mated with their own sire or their inbred half brother. In 10 cases where the daughter was bred back to the sire only two normal calves were secured. In experiments with pigs it was found that with over 50 per cent of inbreeding many runts and weaklings are obtained in the litters. Some attention was also given to the effect of pituitary and thyroid extracts on the runts. The feeding of thyroid extract had no effect.

The study of sweet-potato diseases was confined largely to the so-called pox disease, but progress was also made in the investigation of a number of other diseases. In this work sweet potatoes are grown on several farms and 14 varieties are under observation with reference to their resistance. The conditions required for proper storage of sweet potatoes are being studied in a special storage room prepared for the purpose. It appears that black rot of sweet potatoes is carried with the seed to the bed and from the bed to the field. Stem wilt or yellows is also carried with the seed. Corrosive sublimate gives better results as a seed treatment than formaldehyde. A formaldehyde solution containing 1 pint in 20 gallons of water and used at the rate of 1 gallon per square foot seems to disinfect the soil thoroughly.

Bacteriological changes, due to different soil treatment, were studied, particularly with reference to the effect of humus. For this purpose a specially prepared humus was used. It was found that a number of organisms could be introduced into the soil through this humus material. Moreover the application of wood ashes with molasses seemed to increase the growth of soil organisms. In plate cultures the addition of sodium or potassium carbonate increased the number of nitrifiers. Molasses proved to be an important factor in increasing the number of soil organisms.

Work on yellows, little peach, and russet was continued with particular reference to the causes and manner of distribution of these diseases. Yellows is being studied in connection with mosaic disease of tobacco since it is believed that these diseases may be similar in nature. It was found that the so-called anthracnose disease of cucurbits affects watermelon, cantaloup, citron, and cucumber. Some work was also done on the blossom-end rot. An attempt is being made to secure resistant varieties.

Work with Hatch and other funds.—The agronomy department continued work on 120 plats in rotation experiments with fertilizers. Important data were secured with reference to the effects of lime and fertilizers. The rotation adopted on these plats involves corn, soy beans, wheat, red clover, and timothy. The same plats are used for fertilizer experiments. Considerable work was also done in testing varieties of winter wheat, spring wheat, oats, corn, soy beans, cow-peas, alfalfa, and sweet corn. Evidence has been obtained that the fertility of the soil may be kept up by means of alfalfa and small quantities of commercial fertilizers. A renewal of interest in sugar beets led to cooperative experiments with this crop on 12 farms. Cultural experiments with alfalfa indicated that this crop is most benefited by phosphoric acid, while potash is of less importance. The best results were obtained from the use of 20 pounds of alfalfa seed per acre. American-grown seed from unirrigated districts of the Western States proved most valuable.

The chemical department, in addition to analytical work involved in cooperation with other departments in the conduct of Adams projects, was called upon to do many miscellaneous analyses for the departments of horticulture, agronomy, and animal husbandry. Analyses were also made of miscellaneous material sent in by farmers. A study was begun of the tolerance of wheat seedlings in water cultures as measured by the hydrogen-ion concentration.

The horticultural department continued its work on cover crops for peaches and apples, using about 3 acres of land for each crop in this experiment. Variety tests of fruit were conducted on about 8 acres. Some variety work was started also with beans, tomatoes, and cabbage. A beginning was made of an experiment with peaches to secure a freestone peach of earlier maturity. A considerable mass of data was accumulated also on the problem of transmission of characters in cabbage.

The work of the plant pathology department involved breeding and selection of tomatoes, wilt-resistant cabbage, a study of powdery scab of potatoes, and determinations of the purity and germination of seed. Some evidence was obtained that powdery scab is not carried over from year to year in the soil. The work on wilt resist-

ance to cabbage is carried on in cooperation with the Wisconsin station.

The following publications were received from this station during the year: Bulletins 108, Some New Bacterial Diseases of Legumes and the Relationship of the Organisms Causing the Same; 109, The Diseases of the Sweet Potato and Their Control; 110, Alfalfa in Delaware; and 111, Annual Report of the Director for the Fiscal Year Ended June 30, 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	5,000.00
Farm products	1,893.58
Total	36,893.58

The Delaware station is doing much good work. The station receives little direct assistance from the State and the funds of the college admit of only scant aid. More liberal adjustment, however, has been arranged and there is much encouragement for State aid. The general condition and usefulness of the station merit generous support.

FLORIDA.

Agricultural Experiment Station of Florida, Gainesville.

P. H. Rolfs, M. S., *Director*.

The year was a satisfactory and encouraging one for the Florida station. Extension and station work were sharply separated and the amount of time given by station men to extension service was greatly reduced. The area used for experimental purposes, including the tract leased at Tavares for citrus experiments, was about 135 acres. All the work of the station has been placed upon a project basis. The dairy barn built with funds furnished for the preceding year was completed at a cost of \$10,000. The legislature appropriated \$2,500 for general expenses of the station, \$2,000 for repairs, and \$2,750 for printing. The director was made dean of the college. W. C. Etheridge was appointed professor of agronomy.

Adams fund projects.—The investigation of soils and fertilizers in relation to plant growth made important progress. The work was continued in the citrus grove at Tavares, notes being taken on the effects of fertilizers continuously applied. Comparative observations show more evident differences between the plats than heretofore. The plat which receives no fertilizer has fallen far behind in growth, while the plats fertilized with raw phosphate have not kept pace with those which receive acid phosphate. The clean-culture plats continue to make the best growth. The use of raw phosphate has

not exercised any appreciable effect in correcting the acidity of the soil. Soil acidity appears to be greater in summer than in winter, perhaps on account of the greater activity of soil organisms in summer. In tank experiments at the main station the losses of nitrogen, phosphoric acid, and potash are being studied. In general, losses of nitrogen diminish with the increase of time, while potash losses increase.

The study of plant nutrition with reference to physiological diseases was confined largely to an investigation of the effect of fertilizers on citrus trees, with particular reference to die-back and frenching. Attempts to discover a causative organism of die-back have thus far proved fruitless. Neither has any success followed the attempt to produce die-back by artificial conditions under exact control. Vanillin has been found in comparatively large quantities in soils on which die-back occurs. The work is being conducted by means of laboratory and pot experiments and by field tests. As far as growth was concerned, dried blood has given the best results of all nitrogenous fertilizers. A distinct type of frenching has been found to follow the use of lime. The development of die-back is also favored by the addition of large quantities of barnyard manure and cover crops. There appeared to be certain soils in the State which are injured under certain conditions by the application of limestone. The first effect of the application of limestone is to produce greatly increased tree growth. This condition is followed by a diminution in the amount of the cover crop which in turn has a detrimental effect on the growth of the tree.

In the entomological work of the station chief attention was given to the study of the velvet-bean caterpillar. This is the only serious insect enemy of velvet beans in Florida. It was quite definitely established that the pest does not pass the winter in central and northern Florida but that the annual infestation is due to a migration of the insect from the South. Several natural enemies of this pest are under observation. It appears that spraying or dusting with arsenate of lead every two weeks during the caterpillar season is quite effective. Possibly the insect lives on plants related to velvet beans in southern Florida or may migrate in the spring from Cuba.

A study of thrips affecting the bloom of citrus and other economic plants was continued and quite satisfactory means of control were worked out. The investigation of nematode root knot was taken up actively with particular reference to materials which may be used economically for the control of nematodes. The most promising material thus far is calcium cyanamid which has proved valuable for sterilizing seed beds. Calcium cyanamid, however, penetrates the soil rather slowly. The indications thus far obtained are that in

light trucking soils about 1 ton of calcium cyanamid per acre will be required for satisfactory results.

In the investigation of citrus diseases, attention was devoted chiefly to citrus canker. It has been found that the organism of the disease may live in air-dried soil for a period of 17 months. Living organisms were also found in the soil under previously infected trees, and soils were shown to be contaminated to a depth of 6 inches. Even after thorough sterilization of the surface of the soil by burning, the organism continued to persist in the deeper layers of the soil for five or six months. Many difficulties have been encountered in determining the organism of gummosis. Some doubt was thrown on the possibility of *Diplodia* being the cause of the trouble. Evidence was obtained indicating that fungi are of secondary importance in the disease.

Much attention was given to the study of diseases in seed beds of truck crops, particularly tomato, eggplants, cucumber, and cantaloup. Damping off in seed beds was shown to be chiefly due to a species of *Rhizoctonia*. There seems to be an intimate connection between this disease in the fields and in the seed bed. The most effective means of control was found in a thorough sterilization of the seed beds and treatment of the seed before sowing. The so-called wilt of pineapple received further investigation. In certain areas it seems to be due principally to root knot. Much injury is also caused in pineapple fields by the presence of *Thielaviopsis paradoxa*.

The study of a pecan disease was begun during the previous year. The disease appears to be due to *Botryosphaeria berengeriana*. The causative relation of the fungus was determined by inoculation experiments and some attention has been given to methods of control. The most practical means thus far discovered consists in pruning away the diseased twigs.

Work with Hatch and other funds.—The principal work of the year supported by Hatch and State funds was in animal industry and forage crops. Numerous experiments were in progress with reference to variety, culture, and suitable fertilizers for various Florida crops. Much attention was given to the problems of milk production from feeds grown in Florida. In this work various rations were tested in comparison with commercial rations. Sorghum silage was found to be slightly more economical than sweet-potato silage for milk production. A comparison of sorghum and Japanese-cane silage in wintering cattle showed that animals when fed on sorghum-silage and cottonseed meal for 60 days made an average gain of 8.25 pounds each, while those which were fed on Japanese-cane silage and cottonseed meal simply maintained their weight.

Further fertilizer experiments with Japanese cane confirmed the conclusions previously reached that there is a gradual decrease in

the yield when this crop is grown continuously on the same plat. This gradual reduction in yield occurs regardless of the quantity or quality of fertilizer used. In a period of six years' continuous culture of Japanese cane the crop practically ran out. The plats of cane were fertilized differently, but no definite evidence was obtained as to the cause of the gradual diminution of yield. Where Japanese cane was followed by sweet potatoes, the latter was reduced about 50 per cent below the average, indicating that for sweet potatoes the amount of potash in the soil had been reduced too low. Better yields of Japanese cane have been obtained where the cane is replanted every third or fourth year. No effect of fertilizers upon the sucrose content of the juice was noted.

In some pig-feeding experiments corn, cowpeas, sorghum, peanuts, rape, velvet beans, and dasheens were used in various combinations. Green cowpeas and shelled corn gave better results than sorghum and shelled corn. As the amount of peanuts in the rations was increased there was a noticeable increase in the rate of daily gain per head. The best gains were produced by a ration of 3 parts shelled corn and 1 part cracked velvet beans. Raw dasheens proved to be unsatisfactory as a feed for pigs.

In the preparation of sweet-potato silage one of the difficulties encountered was a tendency of the material to be too wet. Kudzu beans gave little promise of being valuable as a silage crop. Experiments with spineless cactus indicated that this plant is not adapted to Florida conditions.

In other departments also much miscellaneous work was carried on. The chemical department made numerous analyses for other departments, particularly of Japanese cane and other forage materials. The department of entomology accumulated a large mass of data on insect pests and the department of plant pathology continued its study of minor diseases.

The following publications were received from this station during the year: Bulletins 128, Citrus Canker, III; and 129, Japanese Cane.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation, including balance from previous year	8,258.35
Farm products, including balance from previous year	3,284.56
Miscellaneous	2,413.45
Total	43,956.36

The Florida station is devoting its energies chiefly to the citrus industry, dairying, and forage crops adapted to local conditions.

Important contributions have been made in these fields of work, and the station is making its influence felt in the entire agriculture of the State.

GEORGIA.

Georgia Agricultural Experiment Station, Experiment.

R. J. H. DeLOACH, A. M., *Director.*

The Georgia station made progress in the organization and systematic arrangement of its work, and in the technical conduct of its investigations. The work is all on a project basis, the departments of chemistry, bacteriology, and botany being almost wholly supported by Adams funds, while the departments of animal husbandry, agronomy, and horticulture are supported by both Hatch and Adams funds. The station received no other financial support than that of Federal funds, except for the sales fund, which amounted to about \$3,000, and a special appropriation of \$2,500 from the State legislature for use in enlarging and repairing laboratories and other station buildings. In the absence of State funds for maintenance and research, it was impossible to undertake additional work beyond that already in progress. A bill was introduced in the State legislature providing for the removal of the station from its present site to the agricultural college at Athens, Ga., but failed of passage. There were no changes in the personnel of the staff during the year, but soon after its close the director resigned, and the outgoing State commissioner of agriculture, ex officio president of the board, was elected to succeed him.

Adams fund projects.—Further study of the cause of toxicity in cottonseed meal was devoted largely to the balance of acid-forming and base-forming elements in the meal. It was found that 100 grams of cottonseed meal contained an excess of acid-forming and base-forming elements equal to 8.2 cubic centimeters normal acid. Fatal effects were produced within 30 to 40 days by feeding 25 grams of meal per kilogram live weight daily to a pig 6 weeks old. Even twice the quantity of mineral acid represented by the excessive acid in the fatal dose of cottonseed meal did not injure the pigs, although it produced metabolic changes which are characteristic of acidosis. Acidosis therefore appears to play a secondary rôle, if, indeed, it has any influence at all in poisoning by cottonseed meal. A study has been begun on the effect of accessory feeds in connection with lethal doses of cottonseed meal.

The influence of cottonseed meal upon changes in the composition of butter fat received further attention. Evidence was obtained that when cottonseed meal was fed in small quantities it was not

transferred in any large amount directly to the milk fat. The presence of cottonseed oil in milk is usually shown within 12 to 36 hours after feeding, and the maximum effect was observed in about 6 days. While some of the oil is thus transferred to the milk, it appears not to go over as such but to be broken up and metabolized in some manner before appearing in the milk.

The study of the influence of combinations of feeds on the digestibility of components was continued actively. It has been found that starch fed in excessive amounts exercises a depressing effect upon the digestibility of nitrogen, but that this effect can be largely overcome by the addition of cottonseed meal. The influence of corn silage and cottonseed meal on the digestive coefficients of each other is now receiving attention. Evidence has been secured that the nutritive value of a feeding stuff used alone is not necessarily the same as one fed in combinations with other feeds. Within certain limits it appears that the total quantity of nitrogen excreted in the feces is fairly constant even under decided changes in the nitrogen intake and digestibility.

Further study of heredity in the black varieties of Muscadine grapes disclosed the existence of a white variety which is recessive. Many crosses have been made with this variety, resulting in about 400 hybrid plants. Attention is now being devoted to the inheritance of leaf and other characters in these crosses. Cytological studies are also in progress to determine the cause of self-sterility. A beginning was made on the new project relating to self-sterility in pecans. Indications thus far obtained are to the effect that certain varieties of pecans are self-sterile and that hickory, which, like pecans, can be divided into early and late blooming groups, will serve in pollinating pecans.

In comparing the value of the nutritive salt solutions and the soil solution as media for *Pseudomonas radicicola* it was found that the organism retains its vitality and withstands drying under laboratory conditions for five years or longer. In this work plants are grown in large bottles. An attempt is being made to develop strains of nodule-producing organisms which will readily pass from one host to another. No positive results upon this point have been obtained.

In investigating plum wilt the cause of the disease has been determined as a new organism named *Lasiodiplodia triflora*. Certain phases of the disease remain to be studied, especially the method of infection and dissemination. The fungus organism infests principally the conducting tissues and the medullary rays, causing gum formations. It appears that the sudden wilting was due to an interruption of the water supply from the deposits of gum in the fibro-vascular bundles. The fungus gains entrance to trees through

wounds, particularly those caused by peach borers and other wood-infesting insects.

Certain fungi were found to be present in all of the diseased areas in cases of the bacterial canker of Japanese plums, but inoculations with cultures of these fungi failed to produce the disease. The fungi noted in this work are rarely found in young cankers. Bacteria, however, are present and are found also in lesions on the leaves. The bacteria have been determined as *Bacterium pruni* and it is thought that this organism is the primary cause of the trouble.

An apparently new species of *Colletotrichum* has been found in a study of the new leaf-spot disease of turnips. Inoculations have been made with this fungus. The organism not only produced the serious leaf-spot disease of turnips but other cruciferous plants may apparently act as hosts. Satisfactory progress was also made in the study of the relation of Spermatia, or microspores, to the life history of certain Ascomycetes. Inoculation experiments have been made with various spore forms in host plants, but all attempts to induce the germination of Spermatia have failed. In a few forms Spermatia were produced in cultures from other stages of the fungus. A large number of different kinds of leaf spots have been collected for the purpose of studying the perithecia. Some success was had in showing the relation of certain hitherto unknown or merely suspected forms.

In studying the water requirement of cotton, results were obtained indicating that with different percentages of saturation the water requirement increases with the percentage of saturation, the ratio varying from 396:1 at 30 per cent saturation to 651:1 at 90 per cent saturation. The average of all observations indicates a water requirement of 491 pounds for each pound of dry matter. Incidentally during the progress of this work some interesting observations were made indicating a regular mathematical order in the blooming of the cotton plant. A new project for the further study of this phenomenon was organized. Attention is also being given to the relation between the heavy flowering periods of the cotton plant and the water requirement at those times.

Work with Hatch and other funds.—Most of the work of the station supported by Hatch funds is in the departments of agronomy and horticulture. The agronomy department is carrying on experiments to determine the loss of fertility in drainage water, but it has been found that the drains used in this experiment are too long. Fertilizers were applied to corn at different stages of growth to determine the proper time for such applications. Only slight differences were noted in the applications at different times.

Variety tests were carried on with various forage plants. Some selection and breeding experiments are in progress with corn, cotton,

and bur clover. Seeding tests with alfalfa and inoculation experiments with cowpeas are also in progress. Some fertilizer experiments have been begun with oats. In variety tests with cotton, the excellence of the Cleveland variety was shown. Excessive amounts of fertilizers applied to corn proved to be unprofitable. The station is cooperating with this department in testing varieties of soy beans and velvet beans. In preparing soil for alfalfa it was found that 1 ton of ground limestone was hardly sufficient for best results.

Fertilizer experiments with cotton indicated that substantial diminution in the amount of either of the principal elements of plant food resulted in the reduction in the total weight of the plant and a lengthening of the period from form to bloom and also in the maturing of the plant. Evidence was obtained that seasonal variations may notably affect the weight of the seed and its fat content. General studies were also conducted on cultural requirements for alfalfa, rape, and various winter crops, including wheat, oats, rye, barley, spelt, vetch, bur clover, and crimson clover.

The department of horticulture conducted experiments in the control of pear blight with reference to the effect of cultural methods and to possible varietal resistance. One variety of pear has been found which has shown no blight during five years. In fertilizer experiments with sweet potatoes, no relation was found between the kind of fertilizer used and the keeping quality or yield of sweet potatoes. The excessive use of nitrate of soda, however, appeared to give sweet potatoes a poor quality notwithstanding the fact that they kept well. Tomato-breeding experiments with reference to susceptibility to blossom-end rot were continued and third generation hybrids are now under observation. Apparently a resistant type has been obtained. In cooperation with this department a study is being made of crown gall on apple trees. Further work has been done with peach breeding and in experiments on the cultural methods for garden vegetables. Fertilizer experiments with watermelons are also under way. In comparing self-boiled and commercial lime-sulphur solutions for spraying peaches, the self-boiled mixture gave decidedly the best results. A general study of pecans involved varieties and influence of climate, soil, and stock on the scion.

The department of animal husbandry is making a study of the factors which influence appetite in working mules, with particular reference to palatability of the feed, habit, age, condition, amount of work, weather conditions, and individuality of the animal, as well as to the proportion of concentrate to roughage, the nutritive ratio, and methods of preparing the ration. During the year the influence of changing the ration was tested after feeding a certain ration for 100 days. A change resulted in a greatly increased appetite, although

no evidence was obtained that the efficiency of the ration was increased.

The department of botany made a study of the black mold of collards, particularly with reference to the means of dissemination of the disease. Attention was also given to a bacterial stem rot of collard. Further data were accumulated toward a plant-disease survey.

The following publications were received from this station during the year: Bulletins 120, Studies of *Bacillus radicicola*, I and II; 121, Transmission of Resistance and Susceptibility to Blossom-end Rot in Tomatoes; 122, The Changes in Composition of Butter Fat Produced by Feeding Cottonseed Oil; 123, Irish Potato Spraying; Circulars 69, revised, Station Publications, and 74, Report on Corn and Cotton Varieties at the Georgia Experiment Station for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	3,503.21
Farm products, including balance from previous year	2,737.66
Total	36,240.87

For several years past the Georgia station has been making encouraging progress in developing its work and organization under the handicap of no State funds and isolation from the other agricultural work and facilities of the State. Repeated attempts to secure support for an appropriation to supplement the Federal funds have failed, as have also measures before the legislature for removing the station and making it a part of the agricultural college.

By the resignation of Director DeLoach soon after the close of the fiscal year and the action of the governing board in choosing his successor the station has passed out from the management of a technically trained director experienced in the methods and the purposes of experiment station work. The conditions responsible for this action illustrate the extreme difficulty of maintaining the proper standards and understanding of the experiment station, separated by management and by distance from the university and the college of agriculture. This isolation is not only unduly expensive and detrimental to the highest efficiency of the station, but through lack of systematic contact between the station and the college of agriculture the State is deprived of the advantage which should accrue to the agricultural extension work from the activities of the station. These activities and results in other States are the main foundation of the extension work and the college teaching in agriculture.

GUAM.

Guam Agricultural Experiment Station.

A. C. HARTENBOWER, B. S., *Agronomist in Charge.*

The construction work completed during the year gave better housing for live stock and also for tools and machinery. A building was erected for use as a feed storehouse and was so constructed as to permit fumigation to destroy insects. An adequate sewer system was planned and construction work upon it was begun. Considerable improvement was also made upon the lawn, roads, and ornamental shrub plantings. The interest of the inhabitants of the island in the station was shown by an increasing number of visitors. The agronomic work included breeding and variety experiments with cotton, corn, rice, tobacco, and various forage plants. The results of selection by the ear-to-row method are shown by the improvement of the corn crop. Egyptian, Sea Island, and Caravonica cottons did not thrive well during the year. The yields of some of the upland varieties of cotton ranged from 1,000 to 1,800 pounds of seed cotton. The fiber produced by the Sea Island, Egyptian, and Caravonica cottons was rather weak. Cotton, however, is considered as a promising money crop for Guam.

The rice experiments included fertilizer and variety tests. Rather striking results were obtained from the use of fertilizers, but it is considered desirable to repeat these experiments. The forage plants under study at the station included especially alfalfa, cowpeas, soy beans, velvet beans, Kafir, feterita, milo maize, Para grass, guinea grass, and other plants. Encouraging results were secured from tests with all of these plants. Jack beans and pigeon peas were also used for green manuring and other purposes with promising results. Para grass gave evidence of being a satisfactory pasture crop for hogs. It was found that it was necessary to prepare the soil carefully and plant rather closely in order to secure a satisfactory stand of *Paspalum dilatatum*. Guinea grass proved to be quite inferior to Para grass for grazing or hay purposes. Poor success was had in attempts to grow Hungarian, German, and Pearl millets.

The horticultural work of the station was largely devoted to testing and distributing tropical fruit trees, ornamentals, and vegetables. More than 31,000 fruit and ornamental trees and a large amount of vegetable and field crop seed were distributed. Particular attention was given to variety and cultural tests with beans, peppers, eggplants, radishes, carrots, muskmelons, cucumbers, squash, onions, mangoes, pineapples, papayas, and coconuts.

A beginning was made in a study of the cause of the rapid deterioration of vegetable seeds after arriving at Guam. Samples of seeds of various kinds were stored in the laboratory for careful ob-

servation. With certain kinds of garden seeds a gradual diminution in vitality was shown as a result of holding the seed in jars for six to eight months. Further studies were made on methods of propagating mangoes. The native carabao mangoes do not bear profusely. Fertilizer experiments are under way to determine whether the yield of mango fruit may be increased. By means of cultural experiments and the use of fertilizers, it is believed possible greatly to increase the yield of coconuts.

The station is putting forth earnest efforts to improve the animal industry of the island. For this purpose the Morgan horse is being crossed upon native horses. The results thus far obtained are encouraging. In feeding experiments with horses it was shown that alfalfa hay is decidedly superior to Para grass but that the alfalfa should not be fed in quite as large rations as is customary in colder climates. The annual cost of maintaining a mature horse was found to average about \$140. On account of the great prevalence of cattle ticks in the island, it has been found desirable to dip cattle in an arsenical solution at rather frequent intervals. This treatment has been shown to prevent to a considerable extent the high body temperatures which develop as a result of excessive tick infestation. The Ayrshire cattle imported for the purpose of improving native cattle have given a good account of themselves and the results of this crossing are very encouraging.

The improvement of the hog industry is being brought about by the use of Berkshire boars. A feeding experiment was carried on for the purpose of comparing breadfruit and coconuts with imported corn and shorts. The results indicated little difference in cost between the local and imported rations. Considerable difficulty has been experienced in an attempt to introduce milch goats on account of the great prevalence of intestinal worms and other diseases.

Encouraging results have followed experiments in cross-breeding Brown Leghorns, Barred Plymouth Rocks, and Rhode Island Red fowls with native fowls. In a comparative incubation experiment, eggs were used from pure Brown Leghorns, Plymouth Rocks, and crosses between these breeds and native fowls. The highest percentage of hatched eggs was 80 and the lowest 58. Quite conclusive evidence was secured that the introduction of new blood among the flocks greatly increased the vigor of the fowls.

The only publication received from this station during the year was the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation	-----	\$15,000.00
Farm products	-----	474.54
Total	-----	15,474.54

Year by year the Guam station is getting a firmer grasp on the agricultural problems of the island and is becoming a more important factor in its agricultural development. The work of the station is highly appreciated by the inhabitants of the island and cordial co-operation has been received from the naval authorities of Guam.

HAWAII.

Hawaii Agricultural Experiment Station, Honolulu.

J. M. WESTGATE, M. S., *Agronomist in Charge.*

A 13-acre tract on the Schofield Barracks Military Reservation was set aside for the use of the station in conducting experiments with forage crops suited to local conditions for the ultimate object of developing a locally grown ration for the military horses and mules. M. O. Johnson became chemist in place of W. T. McGeorge, who was transferred to the Bureau of Chemistry. C. W. Carpenter was appointed as plant pathologist, and J. B. Thompson was made superintendent of the Glenwood substation, succeeding F. A. Clowes, who resigned. A beginning was made in making a collection of grasses, legumes, and other forage and green-manure crops, as well as of various specimens showing stages of plant diseases.

At the Glenwood substation further studies were made of forage plants suitable for growth under extremely heavy rainfall. The edible canna gave some promise both for forage and human food. The same may be said for Jerusalem artichokes. Some observations were also carried on with reference to the variation in the weight and size of hens' eggs.

The territorial marketing division conducted under the supervision of the station moved into its new building, where much better quarters are provided, and continued its work as in previous years. The division is now in position to offer better service both to the farmer and to the consumer. Special rooms were provided for retail and wholesale purposes and for storage as well as for candling eggs, fumigating seeds, and dressing poultry. The San Francisco branch of the division was occupied in handling shipments of pineapples and other farm produce. During the year the total sales made by the division amounted to \$121,085.78. The products shipped in by farmers for sale included nearly all of those commonly grown in the Territory.

The horticultural work of the station included a study of pineapple seedlings, litchi, breeding of mangoes, avocados, and papayas, and the accumulation of data on miscellaneous tropical fruits. Several thousand pineapple seeds were obtained during the year for use in this study. Considerable improvement was made in methods of germinating pineapple seed and with caring for the young plants. It is

hoped that some valuable new forms may be obtained from these seedlings. Some attention was also given to methods of controlling a mite disease of litchi. In cross-pollination experiments with Chinese wood-oil nut and kukui nut, apparent hybrids were obtained between these species.

The chemical work of the station included a study of various legumes with reference to their value for green manuring. Further investigations were made on the cause of chlorosis of pineapple plants and analyses of cassava and edible canna. A number of wild species of legumes were found to be worthy of further testing as green-manure crops. In experiments on chlorotic pineapples on manganese soil, the application of ferrous sulphate, as in experiments previously conducted at the Porto Rico station, caused the plants to turn green and to make a normal growth. The ferrous sulphate was applied in the form of a spray. The effect is interpreted as meaning that available iron is thereby added to the plant by means of the spray.

The division of plant pathology was inaugurated toward the close of the year and at once began a study of late blight of Irish potatoes, leaf spot of sweet potatoes, late blight of celery, banana wilt, taro rot, and anthracnose of avocado and mango.

The agronomic investigations of the station involved cultural experiments with rice, taro, and potatoes, studies of various legumes for green manuring, and variety tests of grasses and forage plants. Velvet beans, muth beans, and kulthi beans proved to be well suited for use as green manure plants. A leguminous shrub (*Crotalaria madurensis*) gave considerable promise for use in coffee nurseries. Experiments with grain sorghums indicated the availability of several strains for forage purposes. A beginning was made in hybridizing experiments between Japanese sugar cane and other varieties.

The extension work of the station was continued with highly satisfactory results. The difficulties of travel and the isolation of many of the farming districts naturally handicap efforts made to reach some of the farming districts except at irregular and infrequent intervals. Local demonstrations were arranged on land of the leading farms and attention was called to interesting work in progress on these lands. Especial efforts were made to improve methods of marketing farm crops. To this end farmers' cooperative organizations were encouraged to standardize their products, to study market requirements, and to develop more satisfactory methods of packing and handling their produce. An unusual amount of interest on the part of farmers has been manifested in two county fairs, for which preparations are being made, one to be held in Hawaii County and the other in Hilo County. The extension division of the station has taken an active part in organizing these fairs and in perfecting plans to insure their success.

The following publications were received from this station during the year: Bulletins 39, The Biochemical Decomposition of Nitrogenous Substance in Soils; 40, The Soils of the Hawaiian Islands; Press Bulletin 50, The Effect of Arsenite of Soda on the Soil; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation-----	\$35,000.00
Farm products -----	972.68
Total -----	35,972.68

The Hawaii station is successfully continuing its work of studying the conditions which underlie a diversification of farming in the Territory. To this end the operations of the Glenwood substation, the marketing division, and the extension division contribute effectively. The demonstration of the effectiveness of iron sulphate as a treatment for chlorosis of pineapples will greatly encourage the industry of pineapple production.

IDAHO.

Agricultural Experiment Station of the University of Idaho, Moscow.

J. S. JONES, M. S. A., *Director.*

The research work of the station was carried on actively during the year and yielded satisfactory results. There were no important changes in the staff except the appointment of A. C. Burrill as entomologist. He assumed his duties after the close of the fiscal year. Not only did the various departments make encouraging progress at the main station, but the work of the substations yielded many interesting results. The work of the station is arranged entirely upon a project basis. The plan of internal organization appears to be highly satisfactory and to bring about cordial cooperation of the different departments.

A scheme of cooperation, originally planned by the president of the University of Idaho, has been put into effect between the Idaho and Washington stations, involving measures to prevent unnecessary duplication of work and of publications. Bulletin manuscripts prepared by either station are submitted before publication to the staff of the other station in order that the latter may determine whether copies are desired for distribution in the State, in the event of which an additional edition is ordered at the cost of the respective station. The phases of various research problems have been satisfactorily divided between the two stations in order not to duplicate each other's work unnecessarily, and other details of cooperation are settled by conferences from time to time.

Adams fund projects.—The investigation of the duty of water was carried on at Moscow, Lewiston, and Gooding. It was found that the cans at first used in this study were too small and a larger size was adopted. Water was fed into a sand reservoir in the center of the can. The work was duplicated in all three localities on peas, wheat, potatoes, and sugar beets. Careful meteorological records were kept in connection with the investigation. The water requirements at Moscow and Lewiston were nearly the same, while at Gooding they were much higher. For example, the water requirement per pound of dry matter in wheat was 208 to 361 pounds at Moscow and 663 to 851 pounds at Gooding. The cans now in use in these experiments are 3 feet deep, and the water is applied through a perforated pipe running through the bottom of the can.

The project on soil colloids yielded several interesting results during the year. This work involves a study of soils obtained from slick and nonslick spots in various localities, both cropped and uncropped. A much greater shrinkage occurred in the case of slick than nonslick soils, while the water-holding capacity was found to be lower in the slick soils. No essential difference appeared in specific gravity or mechanical texture of the soils. When the clay was separated from the rest of the slick soil it was found to absorb five times as much dye as the same weight of the original soil. It was concluded that colloids may fix dyes in an insoluble form, and that the absorption of dyes may be used as an indicator of colloids.

More than 12,000 seedling apple trees have been grown from hybrid seed obtained during the investigation of apple breeding. The percentage of these seedlings is known, and attention will be given from now on to a study of size and shape of leaf, vigor of trees, earliness, and numerous other characters for the purpose of noting any possible correlations among these characters. The data secured during the year related to diameter of trees, date at which growth starts, color of the bark, color and type of foliage, annual terminal growth, formation of terminal buds, rapidity of growth, etc.

In continuing the bacteriological studies of north Idaho soils attention was concentrated upon two types of these soils—heavy and light type. Magnesium and iron are much more abundant in the heavy than in the light soil. Since large areas of northern Idaho soils are cut-over lands containing excessive quantities of sawdust and partly decomposed wood, a study was made of the effect of sawdust upon bacterial activities. It was found that sawdust greatly diminishes both ammonification and nitrification, but that these processes are restored to a normal degree by the addition of lime. Sulphates depressed and carbonates increased the activity of both ammonifiers and nitrifiers.

The study of factors which influence the protein content of the wheat kernel made encouraging progress. Data have been accumulated for seven years relative to the influence of the varying amounts of irrigation water upon the protein content of the mature grain. It appears that the influence of water upon the milling quality of wheat has been overestimated. In fact, evidence was obtained that there may be a large variation in the amount of water applied without affecting the protein content of wheat. Rather clear evidence was obtained that the available soil nitrogen considerably influenced the composition of the wheat.

The study of the ripening process of apples is now in its third year, although it has been supported with Adams funds for only one year. The work is chiefly a study of the biochemistry of the apple. An attempt is being made to find a physical measure or indicator of the changing composition of the apple, attention being given chiefly to starch, sugar, conductivity, acidity, oxidase, and diastase. The influence of temperature on the hydrolysis of starch is receiving consideration. An experiment is in progress to determine the comparative effects of storage at 4° and 15° C. It has already been found that acidity in the apple decreases at low temperature. The problem as a whole involves a study of the progressive development of the fruit from formation to maturity.

Further work on apple rosette indicates that there are several perhaps unrelated types of this disease. There appears to be a physiological, parasitic, and nutritive form of the trouble. An arrangement has been made with the Washington station whereby the physiological phases of the work will be studied in Pullman, while the Idaho station maintains the parasitic phase of the investigation. A mildew, apparently of a new species, has been found on affected trees and some evidence was obtained indicating its connection with the disease. Spraying with the common fungicides, however, showed no beneficial results.

The study of the European yellow rust (*Puccinia glumarum*) was carried on actively. This rust seems to be particularly injurious to *Triticum intermedium*, a Russian wheat grass recently introduced upon the station grounds. The rust occurs on the leaves, stems, and glumes of the wheat grass, but only on the leaves of wheat. Some variation in susceptibility to this disease has been found among different varieties of wheat.

Work with Hatch and other funds.—The horticultural department continued its work on fruit by-products, particularly on the evaporation of various kinds of fruit. Chemical analyses are being made of all dried fruits. A pruning experiment with four varieties of apples is in progress with particular reference to the merits of summer and

winter pruning in relation to color and yield of fruit. It appears that the color of apples is improved by pruning in August. All varieties yield more heavily as a result of pruning in summer, but the growth of the trees takes place more rapidly when pruning is done in winter. Some observations have been made on the amount of water required to mature apples and on the relation of water to the development of fruit buds and the keeping quality of apples. Variety tests were carried on with gooseberries, loganberries, and blackberries and spraying experiments for scale insects, codling moths, and various other orchard pests. In this work six insecticides were used for the control of San Jose scale. Scalecide gave the best results followed by lime-sulphur and soluble sulphur. A study of the spread of apple scab indicated that some varieties of apples are much less resistant than others. Scab prevails to a much greater extent in rainy weather. The cost of three applications of lime-sulphur was 8 cents per tree, or \$4.08 per acre.

The animal-husbandry work of the station included a study of forage crops for hogs, sheep-breeding experiments, and an investigation of silage made from various legumes and cereal straws. Alfalfa proved to have about the same value for hog pasture as a mixture of peas and oats. The chemical department is cooperating in the study of silage made from various crops. In this work 11 small silos are filled with legumes and mixtures of legumes with straw. The chemical changes are receiving much attention with particular reference to volatile and nonvolatile acids, alcohol, and carbohydrates. A mixture of oats and peas seems to be the most promising material for silage, but the work involves a study of alfalfa, clover, wheat, peas, oats, wheat straw, and vetch.

The general soil work of the station included a number of rotation experiments and a study of the effect of lead in the soils. The rotation experiments were planned to show the effect of various combinations of fertilizers, summer fallowing, and manure on the yields of cereals and forage plants in a three-year rotation. In some of the mining districts an apparent injury has been noted in the soil from the accumulation of lead. The lead was found to be in the form of a sulphate. An attempt was made to convert it into a sulphid by means of ammonium sulphate and gypsum, but without positive results. Leaching of the soil for three months, however, seemed to be quite effective.

The botanical division is carrying on some experiments in the control of Rhizoctonia of potatoes and a mildew of unknown species causing trouble in orchards. This work is in cooperation with the horticultural department. The experiment on Rhizoctonia disease of potatoes involved the use of two varieties of potatoes, the seed of which was artificially infected with different amounts of sclerotia.

The seed from each variety of potatoes was divided into three groups according to the amount of sclerotia placed upon the tubers before planting. All of the tubers were treated with formalin or corrosive sublimate. The results of this experiment are not yet tabulated.

The work carried on at the Aberdeen substation is entirely agro-nomic in character and is supported by State funds in cooperation with this department. Variety tests with small grains and field peas are being carried on together with experiments to determine suitable cultural methods for dry farming in southeastern Idaho. At the Gooding substation 40 acres of land are devoted to experimental work. An extensive pasture experiment with sheep, hogs, and cattle is yielding interesting results. The experiment is designed to gain evidence on the relative value of different forage plants for use as pasture in southern Idaho. Experiments were also under way with different amounts and times of irrigating potatoes, wheat, barley, oats, and alfalfa. The experimental cereal plats at the Gooding substation, as well as at the main station, were in unusually excellent condition.

The following publications were received from this station during the year: Bulletins 85, The Use of Lime Sulphur as a Summer Spray for Apple Scab; 86, Some Poisonous Plants of Idaho; 87, Insect Pests of the Orchards and Gardens of Idaho and Their Control; Circulars 1, Spraying Calendar; 2, Field Peas; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
Farm products, including balance from previous year	4,953.67
Total	34,953.67

The Idaho station enjoys the keen interest and intelligent support of the president of the State university, and there is hearty cooperation and sympathetic understanding between the president and the director. The feeling that research work is to be encouraged as far as funds will allow seems to have had a good effect in stimulating the efforts of the members of the station staff.

ILLINOIS.

Agricultural Experiment Station of the University of Illinois, *Urbana.*

EUGENE DAVENPORT, M. Agr., LL. D., *Director.*

The work of the Illinois station progressed uninterruptedly without essential change in personnel or policy. The State funds available for the use of the station amounted to about \$195,500, of which

\$114,000 was devoted to agronomic investigations and soil surveys. The legislature appropriated \$5,000,000 for the use of the University of Illinois for the current biennium. R. Stewart was appointed assistant chief in soil fertility. D. McIntosh, professor of veterinary science since 1886, died September 5, 1915. W. L. Burlison was appointed associate chief in crop production. T. J. Burrill, professor of botany emeritus, who had been connected with the institution since its opening, died in April, 1916. A genetics building, 40 by 100 feet, was erected during the year. This structure provides offices, classrooms, and laboratory accommodations for breeding experiments.

Adams fund projects.—The principles concerned in the transmission of characters in apple, strawberry, and sweet pea were further investigated. In the case of the apple the problem was studied by means of bud selection, observations on seedling trees, and reciprocal crossing between varieties. A study of the relative value for purposes of propagation of large and small buds has been made and a comparison was also instituted between buds from different parts of the tree and from different positions on the shoot. The results of this work will be published in the near future. A study of seed production in apples involved records on 28,000 fruits. New and extensive plantings were made in the experimental orchards, chiefly with peaches. Only a few varieties of apples have proved to be self-fertile. About 5,000 hybrid seedling apple trees have been planted in the experimental orchards. The extensive development of that phase of the project immediately concerned with apples has made it necessary to curtail work with the strawberry and sweet pea.

The study of the effects of different amounts of the same feeds on digestion and utilization in maintenance and growth has resolved itself into special inquiries in several phases of this line of investigation. Experiments in the nutrition of steers were practically completed, and the data collected are being prepared for publication. A study of feeds with reference to influence of different amounts of protein upon the formation of tissue and bones in pigs was also nearly completed. Some work was done on the protein requirements of lambs. An investigation of the nutritive value of different proteins was actively continued in cooperation with Yale University. In this work particular attention was given to the quantitative determination of amino acids of feeding stuffs and to feeding experiments involving the substitution of isolated amino acids in the place of protein.

The study of unit characters in mammals was continued with interesting results. Data have been recorded on more than 4,000 mice in an investigation of the degree to which different factors are inherited, independently of each other or in conjunction. The factors under study include dominant and recessive spotting in black-eyed

white mice. In the progress of the work it has appeared that the three characters which have been studied longest are not coupled but are inherited independently. The factors which determine the production of roan color in mice have been determined, and it is hoped that the results will prove applicable in breeding farm animals.

Further work was done in crossing normal skunks with albino and black-eyed individuals to determine the laws of inheritance of these mutant characters. In the first-generation hybrids two mutants were shown to be recessive to the normal. These mutants were a pure white and a black-eyed white strain.

Further feed and weight records were taken on offspring of inbred Berkshire sows in the study of inbreeding. The offspring are maintained to the age of 18 months, when they are killed and certain measurements and observations made. The animals under experiment showed a slight tendency toward sterility when closely inbred, and in one group the animals all became sterile. The work on this project is practically concluded.

In a study of breeding by statistical methods the records of nearly 20,000 Shropshire sheep were tabulated with respect to bearing in singles, twins, and triplets. The evidence thus obtained was to the effect that there is a slight but general tendency of one or both twin parents and twin maternal granddams to produce a larger proportion of twins than are produced when the corresponding individuals in the ancestry are singles.

A large amount of work was done in the study of injury to foliage from spraying materials. In applying Bordeaux mixture great variation in the severity of injury was noted. In some cases less injury was produced where trees were drenched, while in other instances a correlation was noted between the amount of spray applied and the amount of injury. When copper ferrocyanid was used in the place of Bordeaux mixture the fungicide proved unsatisfactory but it produced little or no injury to foliage. In general, lime-sulphur injured foliage less than Bordeaux mixture. The leaves previously attacked by seab were somewhat burned when sprayed with lime-sulphur. Much variation in the amount of injury caused by arsenate of lead was noted in the different brands. Paris green caused some injury in all cases and in one instance produced almost complete defoliation.

Work with Hatch and other funds.—The activities of the agronomy department were concerned largely with the soil survey, analytical work with soils, and the operation of 40 fields for soil and crop experiments in various parts of the State. Striking results were obtained from certain fertilizer formulas combined with rational methods of soil improvement. It was shown that nitrifying bacteria

sometimes have the power of bringing raw rock phosphate into solution by means of the nitrous acid which they produce. Breeding experiments with corn with reference to protein and oil content, height of ear, number of ears per stalk, and yield, were continued. In cereal breeding the work included the isolation of productive strains of wheat and oats. Breeding experiments were also carried on with red clover, soy beans, and alfalfa, as well as with sweet clover, millet, sorghum, and broom corn. In the case of corn the yield of first-generation hybrids as compared with their pure-bred parents is being investigated. Some attention is also being given to the physiological effect of detasseling corn. The soil survey has now covered about 60 per cent of the State. Rotation experiments are continued to determine the value of five different rotations in soil treatment. In breeding experiments with corn it was observed that some varieties when inbred remain vigorous, while others lose in vigor. Further work was done on a general system of permanent fertility of the soil, an improved limestone tester was devised, and some attention was given to the question of prices and shrinkage in farm grains.

The animal husbandry department studied the relative cost of maintaining horses and mules for farm labor, the value of rape, alfalfa, and clover forage for hogs, the relative efficiency of grain in finishing calves for market, systems of live-stock marketing, and the cost of growing draft mares from weanlings to the age of 2 years. Valuable records are being accumulated on costs and methods of caring for brood sows. The study of the cost of maintaining heifers and cows has been continued for four years. This work involves a comparison of various winter and summer rations. In the study of methods of raising lambs, Southdown, Shropshire, and Hampshire breeds were used. The lot of lambs which were allowed to run on an acre each of rye, rape, and alfalfa made the same gains and obtained the same market finish as an equal number of lambs on 1 acre of rye and 2 acres of alfalfa.

The chief experimental work of the dairy department was concerned with the study of city milk production, feeding experiments with calves and dairy heifers, and investigations regarding the cost of production of dairy products. The study of market milk is directed chiefly to determining the effect upon the sanitary quality of milk from treating the utensils in various ways.

The horticultural department conducted a wide range of experimental work, including extensive experiments in the control of insects and fungi in apple orchards, tests of the effects of various soil treatments on the production and quality of apples, breeding and fertilizer experiments with lettuce, the study of Fusarium wilt of to-

matoes, fertilizer experiments with roses, carnations, and chrysanthemums, and an investigation of carnation diseases.

The results of spraying experiments in 10 large commercial apple orchards were summarized. These experiments indicated clearly the general effectiveness of spraying. Even under the most unfavorable conditions some benefit resulted from the application of the standard sprays in every series of experiments and in every year of the experiment. In all cases the sprayed plats were conspicuous for their more healthy and vigorous foliage and for the relative freedom of their fruit from insects and diseases. In the use of Bordeaux mixture alone or in combination with arsenate of lead, the smallest amount of control of apple scab was 67 per cent, while the largest was 98 per cent. Lime-sulphur gave benefits ranging from 6 to 100 per cent. In 29 experiments in which arsenate of lead was used this material never failed to exercise some degree of control over codling moth and curculio. The curculio was less thoroughly controlled, however, by arsenate of lead than was the codling moth. In general Bordeaux mixture proved superior to lime-sulphur as a fungicide, but the lime-sulphur produced less injury on foliage and fruit. As a general spraying program for apple orchards the use of Bordeaux mixture before the blossoms open is recommended to be followed by lime-sulphur for the second and third summer sprays.

A comparison of various poisons in combination with standard fungicides for the control of codling moth and plum curculio indicated that Paris green is not only less effective than arsenate of lead but causes more injury to foliage. Arsenate of lead was found to have practically no fungicidal value. Incidentally it was observed during the course of these experiments that lime-sulphur appears to attract codling moth and to repel curculio.

In experiments with nitrate of soda in the production of early vegetables it was found that this fertilizer ordinarily does not induce an excessive development of foliage on early root crops, such as radishes, turnips, and beets, without a corresponding development of the root. Top-dressings of nitrate of soda exercised a beneficial effect upon radishes, turnips, beets, spinach, cabbage, and cauliflower. In the production of vegetables it was found profitable to supply nitrogen to the soil by means of manure and leguminous crops, as well as by the use of even the most expensive commercial forms of nitrogen.

The investigational work in entomology during the year was largely concerned with the study of May beetles and of the influence of trees and crops on injury caused by white grubs. A general survey was made of the whole State for the purpose of securing information on the relative frequency of May beetles and of the particular species which are characteristic of the different parts of the State. Quite

thorough collections were made in 42 counties. The number of species of May beetles found in Illinois is 35, with possibly a few additional species not yet described.

The following publications were received from this station during the year: Bulletins 179 (with abstract), A Biochemical Study of Nitrogen in Certain Legumes; 180, Observations and Experiments on the San Jose Scale; 181, Soil Moisture and Tillage for Corn; 182, Potassium from the Soil; 183, Prices and Shrinkage of Farm Grains; 184, Tests with Nitrate of Soda in the Production of Early Vegetables; 185, Field Experiments in Spraying Apple Orchards; 186, A General Survey of the May Beetles of Illinois; 187, The Influence of Trees and Crops on Injury by White Grubs; Circulars 180, The San Jose Scale; 181, How Not to Treat Illinois Soils; 182, The Fertilizer Problem from the Vegetable Grower's Standpoint; 183, A Bibliography of Recent Literature Concerning Plant Disease Prevention—A Bibliography of Nonparasitic Diseases of Plants; 184 (with abstract), The Prairie Spirit in Landscape Gardening; 185, A Limestone Tester; 186, The Illinois System of Permanent Fertility from the Standpoint of the Practical Farmer—Phosphates and Honesty—When the Doctors Disagree Let the Farmers Judge the Facts; Soil Reports 9, Lake County Soils; 10, McLean County Soils; 11, Pike County Soils; 12, Winnebago County Soils; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	195,500.00
Farm products	38,663.89
Balance from previous year	18,139.58
 Total	 282,303.47

The Illinois station is unusually well supported. With its large staff and extensive equipment of appliances and land it is in position to contribute largely to a wide range of important agricultural problems.

INDIANA.

Agricultural Experiment Station of Indiana, Lafayette.

ARTHUR GOSS, M. S., A. C., *Director.*

The question whether the act of the Indiana Legislature, increasing the tax levy for the university, superseded and repealed the standing appropriations for the station is still pending in the courts. A decision favorable to the station was given in one of the lower courts, but the matter has been appealed and is awaiting final decision.

During the year the station received about the same amount of State money as during the previous year, but much of this money came out of university funds.

The State and sales funds and revenues from fees were as follows: Animal-disease fund, \$5,000; creamery-license fund, \$1,000; creamery-license fees, \$9,903.53; dairy interests fund, \$10,000; feeding-stuffs-control fund, \$66,116.46; general State fund, horticultural interests fund and live-stock-feeding fund, \$10,000 each; poultry interests fund, \$5,000; soil and crop improvement fund, \$15,000; stallion enrollment fund, \$20,049.90; swine diseases, \$15,000; and miscellaneous funds, including sales, \$138,100.47. Many of these funds are essentially revolving funds. The plan of maintaining special lists for distributing station publications was found not to be satisfactory, and it is now felt that a series of popular bulletins will have to be adopted for general distribution in the interest of economy.

Adams fund projects.—The investigation of rusts was continued as in previous years, the main object of the work being the preparation of a taxonomic monograph of the rusts of North America. The results of the studies made in the course of this investigation are published in various botanical journals, including *North American Flora*. The material still to be published is considered sufficient for four numbers and enough material for two numbers is now in manuscript form. During the summer vacation former workers connected with this investigation are brought back to assist in the project. It is expected that the work will be completed in 1918.

The pasteurization of gathered cream in relation to the bacterial flora and keeping quality of butter was actively studied. Work on this project is nearing a close. The purpose of the study has been to determine different methods of pasteurizing cream and their effect on the flavor, keeping quality, and bacteriological and chemical properties of butter. Large lots of cream were mixed in vats and then divided into four portions—the first for churning without pasteurization, the second for churning for pasteurization at 145° F. for 20 minutes, the third for pasteurization at 165° F. by the flash method, and the fourth for pasteurization at 185° F. by the flash method. The churning were made under identical conditions and six 5-pound samples of butter from each were packed in cold storage at temperatures ranging from —5° to 20° F. The butter was scored when fresh and again after 30, 60, and 90 days of storage. Careful chemical and bacteriological tests were made of all samples. The breaking down of protein was a little more pronounced in the unpasteurized than in the pasteurized samples. Butter fat underwent very little change in storage except that the acid value was slightly increased. Differences in flavor were so small as

to be negligible. In general pasteurization improved the quality, flavor, and keeping quality of butter. Moreover, pasteurization seems to drive off undesirable odors, and its effect on the fat globules facilitates the removal of the buttermilk.

The study of orchard management was actively continued with special reference to soil moisture, soil temperature, tree development, and fruit production. Meteorological records under different methods of orchard management were continued. The study also involved analyses of fruits, taking trunk measurements and other growth data, and the determination of leaf weight. Morphological and chemical studies were also made on the leaves. Some attention is being given to the question whether roots tend to avoid soil acidity or other soil conditions. The soil studies in this project during the year were confined to moisture and bacteriological examinations with reference to ammonification, nitrification, and nitrogen fixation. An improved soil sampler for bacteriological work has been devised and has given good satisfaction. In connection with this project, the action of carbon dioxid in relation to soil aeration is being studied in the greenhouse, particularly with peppers.

The study of hog-cholera virus was actively continued, efforts being devoted, as in the preceding year, to obtaining a vaccine from virus by the use of heat. Attention was also given to the virulence of virus from cholera hogs in different stages of the disease and to the use of bacteria-free filtrates diluted with physiological salt solution for use in conferring hyperimmunity. Studies were also made of resistance of virus to different conditions. The attempt to isolate a specific microorganism from hog-cholera blood and blood filtrates was continued but without success. The work thus far done in connection with this project indicates that under field conditions vaccination alone will not accomplish the eradication of hog cholera but that sanitary control measures must play an important supplementary rôle.

Work with Hatch and other funds.—The work of the animal-husbandry department included a large variety of experiments. A comparison was made of heavy and light feeding to determine to what extent rough feeds may be used in fattening cattle. An experiment with molasses feeds indicated that these feeds are unsatisfactory for use in balancing rations. No increase was produced, but they seemed to have a beneficial effect upon appetite. Silage was used in a feeding experiment with 225 western range lambs which received a grain ration containing corn and either cottonseed meal or soy beans. The results from soy beans were satisfactory, while cottonseed meal appeared to be less efficient. The addition of molasses to this ration failed to improve the appearance of the lambs but increased the cost.

On silage alone the animals lost appetite in about two months, but in connection with other roughage the silage appeared to be an efficient ration. Similar experiments were conducted with beef cattle. The feeding experiments with steers included a comparison of corn silage and leguminous hays with leguminous hay alone as roughage, a comparison of soy beans and cottonseed meal, a comparison of clover hay with alfalfa hay, and a comparison of cane-feeding molasses with mixed molasses feed.

In feeding experiments with poultry the value of meat scrap, fish scrap, and skim milk was compared in rations for laying pullets. The pen which was fed skim milk laid somewhat better in December and January than the other lots. The pen which received meat scrap averaged 135 eggs per pullet, that which received fish scrap 128 eggs per pullet, and that which received skim milk 135.4 eggs per pullet. It cost an average of 8.5 cents to produce 1 dozen eggs in the meat-scrap pen, 9.7 cents in the fish-scrap pen, and the same in the skim-milk pen. In the matter of profit the best results were obtained from skim milk. The animal-industry department continued its work on stallion enrollment in accordance with State law.

The chemical department was largely occupied, as heretofore, in the official inspection of fertilizers and feeding stuffs. About 1,400 samples of fertilizers and more than 3,600 samples of feeding stuffs were analyzed. The investigational work in chemistry at the station is done in the different departments, many of which have their own chemical laboratory.

The work in dairy husbandry included the study of the distribution of moisture and salt in different parts of the butter package and a study of the effect of cooling tanks for handling cream on the farm. A considerable lack of homogeneity was noted in moisture and salt in different parts of the butter package. It is quite possible therefore that samples taken by inspectors may not be representative of the whole package. In studying the effect of cooling tanks in handling cream, attention was given to the chemical composition, bacterial content, quality, and market value of the resulting butter. On two of the university milk routes, one-half the number of farms put in cooling tanks, with the result that the butter increased its score by 2.5 points and its value by 1 cent per pound.

The entomological department devoted its efforts largely to a study of the codling moth and Hessian fly. It appears that the codling moth in the northern part of the State is changing its habits somewhat. A large percentage of insects enter the fruit from the side rather than from the calyx end. Apparently, therefore, in practice orchards are not generally sprayed early enough, since the first brood enters the side of the fruit to about the same extent as the

second brood. Some attention was given to the question of the proper time of sowing wheat to prevent injury from the Hessian fly. In some parts of the State parasites are beginning to show a pronounced effect in controlling this pest.

The horticultural department conducted pruning experiments to ascertain the relation of the type of pruning to the methods of cultivation and also carried on tests of cover crops, including soy beans, vetch, crimson clover, rye, and millet to determine their influence on soil moisture and bacteriological and chemical changes in the soil. Some attention was also given to a study of the effect of adding straw in different stages of decay to the cover crop.

The botanical department continued the study of weeds, particularly red sorrel. Some attention was also given to a Fusarium disease of wheat, which appears to be carried over in the seed. Work was also done on the mosaic disease of the tomato. No organism was found in cases of this disease, but it was shown that the disease is readily transmissible. A blight-resistant strain of tomato was tested, but without satisfactory results. A cooperative arrangement between this department and the Michigan, Indiana, and Wisconsin stations was entered into for the study of pickle diseases.

The veterinary work of the station included the production of hog-cholera serum and virus, the supervision of commercial serums produced in the State, studies of cholera-blood filtrates, attempts to attenuate hog-cholera blood, determination of its virulence at different periods of the disease, and an investigation of infectious abortion with particular reference to the diagnosis of the disease.

In the department of soils and crops a wide variety of experiments was carried on, involving about 100 projects. The results of rotation and fertilizer experiments which had been in progress for 25 years were prepared for publication. A new experimental field for the continuation of similar work has been selected. The new field is to be devoted largely to sugar-beet culture and the experiments will have reference to spacing, fertilizers, and the effects of sugar beets in the rotation as compared with corn. During the year experiments were begun at the Bedford farm with fertilizers for wheat and for different rotations. A comparison of various forms of phosphates will involve the use of 34 plats in each of the three-course rotations, or a total of 102 plats.

On the Wilson farm, which has been leased since 1913, fertilizer experiments with phosphates similar to those under way on the Bedford farm have been inaugurated. A comparison of grain farming with live-stock farming is being conducted in connection with a four-course rotation. Numerous variety tests were also under way with practically all the important field crops. Studies were made of the lime and fertilizer requirements of alfalfa and of the value

of rock and acid phosphate for this crop. Moreover, numerous plant-breeding experiments were conducted with cereals and other forage crops.

The following publications were received from this station during the year: Bulletins 180, Commercial Fertilizers; 181, Commercial Feeding Stuffs; 182 (with popular edition), Poultry Investigations, I; 183 (with popular edition), Cattle Feeding, XI; 184 (with popular edition), Sheep Feeding, V; Circulars 25, revised, Agricultural Extension, IX; 53, Stallion Enrollment, IV; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	91,000.00
Individuals	2,706.42
Fees, including balance from previous year	96,072.89
Miscellaneous, including balance from previous year	167,607.18
Total	387,386.49

By requirement of State law the Indiana station devotes a large amount of energy to inspection work in connection with fertilizers, feeding stuffs, stallion enrollment, and serum manufacture. Nevertheless important advances are being made in the research work of the station, particularly in botany, horticulture, field crops, and veterinary medicine.

IOWA.

Iowa Agricultural Experiment Station, Ames.

C. F. CURTISS, M. S. A., D. Sc., *Director.*

While the Iowa station has acquired considerable land in recent years, particularly for agronomic experiments, urgent need is felt for additional land for the use of the animal-husbandry section. A new hog house was completed during the year at a cost of \$1,000 and a new horse barn on the dairy farm at a cost of \$5,000. Provision was also made for the erection of a dairy barn to cost \$18,000. The animal-husbandry section has completed plans for a general laboratory building. A fruit house and implement shed were built for the horticultural section. The offices and laboratories of the bacteriological section are soon to be transferred to the new science building. A grain elevator and storage building has been planned for the use of the animal-husbandry section. The laboratories of the soils section were equipped with a large amount of new apparatus.

Changes in the station staff involved the resignation of J. B. Davidson in the agricultural-engineering section and of four assistants in various sections, as well as the appointment of six new assistants. All of the work of the station has been arranged on a project basis. The number of publications issued during the year was 36.

Adams fund projects.—The study of Mendelian unit characters in cattle breeding yielded some interesting results. Quite important data were secured on color and horn inheritance in crosses between Galloway and Shorthorn cattle. It appears that the black and red pigment in cattle constitutes an independent pair of allelomorphic characters. White animals seem to be the result of pigment in a restricted condition, due to the absence of a factor for extension. The allelomorphic nature of the horned and polled condition in cattle was also indicated by experimental evidence.

The influence of feed, environment, and breeding on native, unimproved cows and their offspring has been under investigation for several years. The results indicate that scrub cows increased rapidly in production under favorable conditions up to the fourth lactation period, when they produced 59 per cent more milk and 54 per cent more fat than during the first period. While these results were obtained with young cows, no decided increase was shown with old cows. The daughters of all pure-bred bulls used in the experiment, with the exception of one, proved to be much better milk producers at the age of 2 or 3 years than their dams as mature cows. In persistency of milk production the grades were intermediate between the scrub and pure-bred cows in the herd. No appreciable difference was observed between the scrub and pure-bred calves as to coefficient of digestion.

The investigation of the relation of organic matter in the soil to crop production was continued actively. Much attention was given to methods for the determination of amino acids and nitrates in soils. A modification of the aluminum reduction method was found to be satisfactory. No tendency was observed for the amino acids to accumulate in lime or acid soil or in heavily manured and limed soil. The amino-acid nitrogen was found in the soil in less amounts than ammonia nitrogen. Soils with higher amounts of manure showed a decided decrease in the amount of nitrate nitrogen at first, but an increase after four to six weeks. In the study of the soluble nonprotein nitrogen of soils the results secured from precipitation of the alkaline extract in trichloracetic acid seemed to indicate that the non-protein fraction may contain most of the simpler nitrogenous compounds. It appears that a large part of the soil phosphorus is organic in nature. A method was devised for determining the total

organic phosphorus in dilute alkali extracts of soils rather than the total organic phosphorus content of soils.

In continuing work on the apple-breeding project, 300 or more new strains of apples which fruited during the year were studied with reference to the unit characters and the performance records of parents as related to these characters. The comparison of varieties as to their resistance to the rapid fall of temperature from -10° to -60° F. indicated that a sudden drop in temperature is more injurious than the actual degree of cold. All twigs not previously dried were injured to some extent when held at a temperature of -10° F. for 20 minutes, but the injury was less in the hardier varieties. Many indications were noted of morphological differences between hardy and tender varieties, but it is still impossible to designate any one test by which the degree of constitutional hardiness of the seedling apple may be foretold.

The study of humus in its relation to the physiological activities of the apple was continued without change of plan. Further data were gathered on soil temperature, diameter of trees, average weight of leaves, twig growth, yield, color, and size of fruit.

Work with Hatch and other funds.—The animal-husbandry section conducted a large amount of experimental work in connection with 30 or more projects. It was found impossible to fatten 2-year-old steers with a maximum profit on heavy feeds of cheaply produced silage with about one-fourth of a ration of high-priced corn. Cooperative experiments in baby-beef production showed this industry to be highly profitable as a farm enterprise. In the use of the self-feeding method for swine the profit from the fattened animals was about \$1 more per head than from swine fed by the ordinary method. Of the various methods of feeding corn to lambs, the best results were obtained from feeding ear corn simply broken. Further evidence was obtained of the value of soiling crops in supplementing pastures. It was found possible to limit the acreage of pasture and also the concentrates fed in summer when soiling crops are avoidable. Feeding experiments with poultry indicated that corn is equal if not superior to wheat, pound for pound, both for growth and for egg production. Some experiments in the production of capons gave evidence that the larger general-purpose breeds of poultry may be most profitably utilized for this purpose. A comparative test of nest eggs indicated that natural eggs are preferred by hens.

The agronomy section carried on a wide range of experimental work. A large amount of seed of pedigreed oats produced at the station was tested in various parts of the State. Quite satisfactory results were obtained from the general use of the scarifying machine perfected at the station for use on hard legume seeds, particularly

sweet clover. Cooperative experiments with pedigreed wheat, originated at the station, gave evidence of a superior hardiness in this variety. A soil survey was conducted in Bremer County. The demand for such surveys was so insistent that further work along that line will probably be done. In addition to the field experiments on the agronomy farm at the station, the soil work involved studies at 30 experiment farms in different parts of the State. A variety of oats with a high yield and stiff straw, resistant to lodging, has been developed. Several strains of timothy of superior value have been originated and are under observation. In a study of the Wisconsin drift-soil area of Iowa it was shown that the maintenance of the proper supply of organic matter in these soils may best be accomplished by the use of farm manure. The addition of phosphorus and potassium seemed to be necessary considerations in systems of permanent fertility but are not limiting factors at present.

The chemical section devoted much attention to the study of silage. Rape and a mixture of rape and legumes produced the best quality of silage. The relative influence of microorganisms and enzymes in the production of silage was under study, but the results are not ready to be announced. The addition of 20 per cent of rape greatly simplified the problem of ensiling legumes. The chemical section also performed numerous analyses of forage plants, animal materials, and other agricultural products in cooperation with other sections of the station. Much attention was given to the chemical composition of insecticides, particularly lime-sulphur preparations. A method for the determination of alcohol in fermenting mixtures was developed.

The horticultural and forestry section conducted a large number of experiments in pomology, forestry, landscape gardening, and truck gardening. The preservative treatment of fence posts was studied with reference to the efficiency of various chemicals used for this purpose. It appears that woods commonly used for fence posts have double the durability shown in the natural state after treatment with creosote. Allowing for all items of expense, it appears that cresoting reduces the annual cost for fence posts on the farm by about one-half. Some attention was also given to the marketing of forest products from farm woodlots and planted areas. The work in truck crops included studies of sweet corn for canning and roasting ears, the effect of environment on the quality of sweet corn, potato diseases, particularly early and late blight, the condition of seed tubers as related to production, and study of cabbage yellows. Spraying experiments were carried on in several orchards and some attention was given to the management of vineyards, orchard heating, cold storage of fruits, and fertilizers for orchards.

The entomological section continued the study of a bee disease of unknown origin. For honey production it was found that the 20-frame hive is too large for best results. Considerable attention was given to the life history and the means of controlling white grubs, strawberry leaf rollers, and other injurious insects.

The section of agricultural engineering conducted tests with tractors, prepared plans for barns and other farm buildings, and collected a mass of statistical data on the efficiency of farm buildings. Tests were also made of the resistance of road materials and the efficiency of plows. Further observations were made on the pressure of ear corn in the crib and on the conductivity of silo walls.

The work of the botanical section included studies of cereal rusts, diseases of corn, potatoes, cabbage, and sweet clover, and the investigation of seed production and weeds. It appears that the setting of the seed pods in alfalfa depends upon the proper functioning of the pollen and a suitable supply of moisture. A study of the Fusarium disease of corn indicated that it was widespread throughout the State. It was found to be an easy matter to inoculate corn plants by spraying them with pure cultures of the organism. A serious Fusarium disease was also found on sorghum. The botanical section also makes general studies of the purity and vitality of seeds and continues its observations on the distribution and means of combating weeds. In a study of the late blight of potatoes it was learned that when potatoes infected with late blight are held at a temperature of 38° F. the loss from the disease is slight. Early digging of blight-infected potatoes appears advisable, therefore, only when the potatoes can be marketed and used at once.

The work of the bacteriological section was largely concerned with a study of fermentation in bread making, the bacterial flora of the intestinal tract of the honeybee, milk bacteria, and the fermentation of sauerkraut. Two yellow milk organisms were isolated and carefully studied—*Bacillus synxanthus* and *B. aurantinus*. The odor and flavor produced in cream by the former organism are very objectionable. A study of these two organisms, however, indicates that possibly an organism may be found suitable for use in the production of color in butter. An investigation of ropy and slimy milk showed that *Streptococcus lacticus*, when inoculated as a starter in milk, may sometimes produce ropiness. *Bacterium viscosum* was also shown to be a common cause of slimy milk. In some cases there appeared to be a direct relationship between chain formation in *Streptococcus* and a development of ropiness. Some attention was also given to the study of gas-forming bacteria in soft cheese, bacterial flavors and odors of milk, and laboratory methods for bacteriological study.

The farm-management section conducted a farm management and rural sociological survey in one township. Further work along this line is contemplated for the coming year. A study was also made on the problem of farm leases in Iowa. It appeared from this investigation that the most successful farms required that the tenant have a working capital of about \$6,000 unless the farms are rented on the stock-share plan.

The following publications were received from this station during the year: Bulletins 156, Pasteurization of Cream for Buttermaking, I and II; 157, Improving Iowa's Peat and Alkali Soils; 158, Preservative Treatment of Fence Posts; 159, Farm Leases in Iowa; 160, Grape Pruning—The Spur and Long Cane Systems Compared; 161, Maintaining Fertility in the Wisconsin Drift Soil Area of Iowa; 162, Two Strawberry Slugs; 163, Late Potato Blight in Iowa; 165, Influence of Environment and Breeding in Increasing Dairy Production; Research Bulletins 17, The Determination of Ammonia in Soils; 18, Sulfofication in Soils; 19, Bacteriological Studies on the Coagulation of Evaporated Milk; 20, Bacteriological Studies on Two Yellow Milk Organisms; 21, Hardiness in the Apple as Correlated with Structure and Composition; 22, Slimy and Ropy Milk; 23, Relation of Moisture to Seed Production in Alfalfa; 24, Determination of Amino Acids and Nitrates in Soils—Amino Acids, Ammonia, and Nitrates in Manures and Limed Soil; 25, Bacterial Activities and Crop Production; Circulars 23, Common Corn Insects; 24, Fertilizing Lawn and Garden Soils; 25, Facts About So-called Hog-cholera Cures and Species; 26, Successful Swine Rations for the Corn Belt; 27, Renewing the Shelterbelt; 28, Seed Corn for the 1916 Crop; and 29, White Grubs in Iowa.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	115,500.00
Farm products	25,196.93
Miscellaneous	30.45
Balance from previous year	5,318.46
Total	176,045.84

As evidenced by the long list of active projects, the Iowa station is earnestly engaged with the important, practical, everyday problems of the farm. Perhaps a preponderating proportion of the work of the station is in the nature of practical experiment rather than of scientific research. The research work of the station, however, is calculated to open the way for a better understanding of practical farm problems.

KANSAS.

Kansas Agricultural Experiment Station, Manhattan.

W. M. JARDINE, B. S. A., *Director.*

The work of the Kansas station was aggressively continued without important change of policy or personnel. The organization of the station has been thoroughly planned and operates satisfactorily. Allotments of funds were made to the various departments at the beginning of the year, and all the work of the station is on a project basis. Five branch stations are maintained under the direction of the central station.

The income of the station from State appropriations included \$40,000 for general purposes, \$22,500 for the Fort Hays branch station, \$6,000 for Garden City branch station, \$4,000 for Colby branch station, \$2,500 for Tribune branch station, and \$2,000 for Dodge City branch station, in addition to \$3,000 for a refrigeration plant and \$1,000 for a poultry laboratory. Numerous additions were made to the scientific equipment of the laboratory of plant pathology and in the chemical and milling laboratories. G. K. Helder, superintendent of Fort Hays substation, was succeeded by Charles R. Weeks. D. E. Lewis, assistant in fruit and vegetable disease investigations, resigned. More than 20 scientific articles were published during the year by members of the station staff in scientific journals.

Adams fund projects.—The study of climate as related to injurious insects was greatly furthered by the use of devices for controlling temperature and humidity. A refrigerating apparatus was installed for maintaining low temperatures in summer. Particular attention was given to the Hessian fly. Its life cycle was found to occupy 23 days, and evidence was obtained that there are five broods in a single season. The results obtained under these controlled conditions are being compared with the life history of Hessian flies in the insectary, where four or five weeks may be required for the life cycle in changeable or unfavorable weather. Incidentally it has been found that the Hessian fly may migrate several miles. Further work on the chinch bug showed that only two broods a year can be produced under favorably controlled conditions. The life history of the chinch-bug parasite was carefully worked out, about 2,000 chinch-bug egg parasites were reared during the summer, and notes were made on the percentage of infestation for each month.

In the study of inheritance in grasshoppers work was done with very large numbers of these insects and some of the breeding tests were carried on in an apparatus in which constant temperature was maintained. In one instance the germ plasm appeared to be affected

by change of environment and a definite modification was thus obtained which reproduces itself like an inherited character. Some progress was made in rearing, under controlled conditions, suspected intermediate hosts of tapeworms of fowls. A study of the transmission of fowl nematodes by eating earthworms indicates that this is a case of association rather than of parasitism in the earthworm. When young chickens were placed in fly-proof cages immediately after hatching they did not become infested with tapeworms. Flies, crickets, and two forms of earthworms are being studied as possible carriers of the fowl tapeworms.

Some interesting results were obtained in the further study of the physiological effect of alfalfa hay cut at different stages. In general it was found that the more mature hay made the better horse feed, being most valuable when cut in time of full bloom. Detailed notes were taken on the laxative and other physiological effects of alfalfa. The horses used in this experiment are fed exclusively on alfalfa and corn. Alfalfa cut in the bud stage showed the largest percentage of ash and crude protein. In each successive stage the crude fiber and nitrogen-free extract was found to increase. The leaves and stems differ somewhat in content of ash, ether extract, and nitrogen-free extract, but chiefly in the percentage of crude protein, which is two and one-half times as great in the leaves as in the stems. Alfalfa hay cured in the sun proved to have a larger protein content than that cured in the shade.

Work was continued on a study of the influence of nutrition upon the form of growing animals. The beef phase of this project has been completed and attention is now being given to swine, particularly the effect of corn on growing pigs. Feeding experiments indicated that corn as a sole diet for growing pigs is deficient both in protein and ash. When pigs were fed a protein free from ash in addition to corn meal, an increased growth was induced. The replacement of a part of the corn protein by casein gave considerable gain over that obtained by corn alone.

The plans for conducting the project on sex type as related to functional development and performance were further perfected in cooperation with this department. At present the plan involves a period of 20 years' investigation. An attempt will be made to determine whether there is a type within the breed which is controlled by sex. A careful record is being kept of the milk and butter fat production of all the cows used in the experiment.

In continuing the investigation of alfalfa breeding, strains of *Medicago falcata* producing rhizomes are used for the drought-resistant factor and are crossed with pure lines of common alfalfa. In this work 30 pure strains of common alfalfa and 36 strains of

M. falcata have been used. Individual plants, showing the most desirable qualities, are selected each year for further propagation.

Work with Hatch and other funds.—The entomological department has been conducting insecticide experiments with the corn-ear worm for several years and secured best results from dust applications at silking time, using lead arsenate and sulphur. About five applications have given best results, but it is believed that three may be satisfactory. Some work was also done on fruit insects, grasshopper control, and a study of the life history and habits of the corn billbug, Kafir ant, wireworms, white grubs, and termites. White ants attack nursery stock and many field crops. A study of the distribution of the Hessian fly showed that it is present in 83 counties of the State. Nicotine sulphate proved effective in controlling appleleaf skeletonizer. Poisoned-bran mash was used successfully against cutworms, army worms, and crickets.

The agronomy department conducted work in soil fertility, commercial fertilizers, seed-bed preparation, the cause of winterkilling of cereals, crop-improvement experiments, farm-management surveys, and experiments in grazing. In cultural experiments with corn it was found that the listing method is adapted to regions with limited rainfall, while the surface planting method is best adapted to regions with abundant precipitation and heavy soils. A study of the effect of dynamite in the improvement of clay soils gave largely negative results. Moisture determinations, extending over a period of three years, showed no marked difference on dynamited and undynamited soils. No difference was observed with respect to nitrate. The physical condition of heavy soils was somewhat injured and fruit trees on affected soils made a slower growth than without the use of dynamite. A study of the relation of moisture to wheat yield showed that late-fall plowed ground contains 2.7 per cent of moisture at seeding time, early-fall plowed ground 4.2 per cent, and summer-fallow ground 8.8 per cent. A large amount of work was also done on soil surveys, particularly in Cherokee and Reno Counties.

The animal-husbandry department carried on feeding experiments with steers, a study of inheritance in swine, and breeding and feeding work with fowls. In feeding experiments with chickens an attempt is being made to determine the constituent of buttermilk which gives it its great feeding value. In this test lactic acid, casein, and milk sugar are being fed separately. Cystin is also being used to determine whether it is able to overcome the effect of feeding casein. In a study of the fertility of swine it was found that herd-book data, while presenting some sources of error, are accurate enough to be suggestive and useful. It appears questionable whether the size of the litter represents the hereditary factors transmitted. A study of sex-limited color in Ayrshire cattle indicated that black and white

color is a simple allelomorph of red and white color, that in the male the black and white character is dominant, while the red and white is dominant in the female.

The horticultural department conducted experiments on berries, fruit-bud formation, and garden crops, including potatoes. An attempt is being made to determine how much alfalfa can be grown in orchards without injuring the trees in a young stage. Attention is being given to the effect of pruning on bud formation. Work is also being done with the ever-bearing strawberry. The potato investigations were confined to a study of fertilizers and varieties, particularly in a rotation.

The botanical department studied the water requirements of hybrid corns, varietal resistance of sorghum to smut, and the resistance of wheat to rust. A hybrid corn was obtained which stood next to dwarf milo maize in point of economy of water. A study was made of the relation of weight of roots to weight of tops in corn and sorghums with reference to drought resistance. Some work was also done on the inheritance of aleurone color in several strains of corn. In the study of sorghum smut the seed is artificially inoculated. About 119 pure-line varieties of winter wheat are used in an experiment on the relative resistance of these varieties.

The dairy work of the station involved a general study of heifer development on a ration of alfalfa hay for the first six weeks followed by alfalfa hay and silage and grain. This work will be continued on 24 heifers through four periods of lactation. A study of alfalfa silage is being made in cooperation with the chemical department. In this work attention is being given to means of preventing putrefaction of alfalfa silage. It was found that fermentation of silage is largely due to microorganisms of four groups—the acid, colon, yeast, and miscellaneous group. The acid group appears to be of most importance. The chemical department performed a large amount of analytical work in connection with studies on soil fertility and feeding experiments. An investigation was also begun of the efficiency of amino acids in the diet of laboratory animals.

The milling investigations involved a large number of baking tests, in which it was shown that egg albumin in baking powder has no effect upon the amount of baking powder required. A study is also under way to determine what organisms produce ropiness of bread. In a study of the milling and baking quality and chemical composition of wheat flour, as influenced by storing, heat, moisture, and germination, it was found to be quite possible to treat new wheat with moisture and heat so as to bring about an actual improvement in the milling quality. Incidentally it was shown that the degree of heat used for destroying mill insects does not destroy the wheat or

flour. Germinated wheat was found not to be badly injured in its milling or baking properties.

The veterinary department continued its study of serum and virus vaccination of blackleg, with particular reference to the germ-free vaccine. About 6,000 healthy cattle were vaccinated with germ-free vaccine with success. Serum followed by pellets also gave a high degree of immunity. The new serum-virus is thus far rather expensive. Further attention was given to methods of destroying prairie dogs and to practical methods of reforestation.

The following publications were received from this station during the year: Bulletins 204, Commercial Fertilizers; 205, Growing Corn in Kansas; 206, The Relation of Moisture to Yield of Winter Wheat in Western Kansas; 207, Soil Survey of Cherokee County, Kansas; 208, Soil Survey of Reno County, Kansas; 209, The Use of Dynamite in the Improvement of Heavy Clay Soils; 210, Smuts of Grain and Forage Crops in Kansas; Technical Bulletins 1, The Milling and Baking Quality and Chemical Composition of Wheat and Flour as Influenced by Different Methods of Handling and Storing, Heat and Moisture, and Germination; 2, Some Important Fermentations in Silage; Circulars 50, Kansas Live Stock Remedy Law, with List of Remedies Registered April 1, 1915; 51, Improving the Kansas Egg; 52, The Kansas Feeding-stuffs Law—Revision of 1913—Amended 1915; 53, Filling Silos; 54, The Prairie-dog Situation; 55, Trees for Kansas; Inspection Circular 1, Analyses of Inspection Samples of Fertilizers; and the Annual Report for 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams act-----	15,000.00
State appropriation-----	84,091.54
Fees-----	23,337.85
 Total-----	 137,429.39

The affairs at the Kansas station are in a very satisfactory condition. The station is well supported by the State, is liberally treated by the college, and is addressing itself in a thorough and systematic way to the leading problems represented by the various conditions in the State.

KENTUCKY.

Kentucky Agricultural Experiment Station, Lexington.

J. H. KASTLE, Ph. D., Director.

The policy and organization of the Kentucky station continued without essential change. Distinct progress was made on the research projects and in the general experimental work. The income

of the station from State and local sources included \$50,000 State appropriation, \$25,000 from fertilizer inspection, \$20,000 from feeding-stuff inspection, nearly \$39,000 from serum laboratory, \$30,000 from food and drug inspection, and \$17,000 from sales funds. The office of dean of the college was separated from that of director of the station. A live-stock barn and tile silo were erected. A department of diseases of live stock was established at the beginning of the year, with R. Graham in charge. P. L. Blumenthal was appointed research chemist and E. H. Nollau resigned to accept a position in connection with the *Experiment Station Record* of this department. J. H. Kastle, director of the station, died September 24, 1916.

Adams fund projects.—The study of the organisms of leguminous root tubercles was continued actively with special reference to the morphology of the organisms on different species of plants. Special staining methods have been devised for the intimate study of these organisms. Attention was devoted chiefly to the organisms on sweet clover and alfalfa, but those on other legumes will also receive consideration. Many cross inoculations were made to determine the number of distinct strains of nitrogen-fixing organisms.

The project on corn-ear worm was nearly completed, but some additional work remains to be done with reference to the life history of this and related species. Further work on the locust borer confirmed previous observations made at the station that the adults of this species feed largely on the pollen of various species of goldenrod. The adult beetle appears late in August and from that time until the end of October feeds on pollen of goldenrod, particularly *Solidago ultissima*. Since the adult beetles seem to be dependent on goldenrod pollen it is suggested that these plants in the vicinity of locust plantings be destroyed or sprayed with arsenate of lead in September. The locust borer was found not to be evenly distributed over the State, but to occur in largest numbers on open tracts where goldenrod is most abundant.

Considerable progress was made on the project relating to the immunization of horses and cattle against contagious abortion. The results obtained from the use of methylene blue and urotropin were not uniform in different herds. Rabbits were successfully protected against the disease by the use of bacterins. A reinfection of the dairy herd of the station was checked by the use of methylene blue. Contagious abortion was also observed in sheep and swine.

Considerable difficulty was experienced with methods of investigating the availability of the potassium of insoluble silicates. When the rock was finely ground and passed through a sieve, the results seemed to be fairly concordant. Bacteria were found to increase the available potash, while yeasts appeared not to have that effect. An effort is being made to determine the nature and quantity of

fatty acids in the soils with reference to their effect on availability of potash.

The study of the significance of sulphur in permanent soil fertility was continued on eight types of soil to which various forms of sulphur were added. The work is conducted in laboratory and greenhouses with soy beans, clover, oats, alfalfa, and wheat. On some of the soils increased production followed the use of sulphur, while on others there was a diminution in yield when sulphur was added at the rate of 100 to 200 pounds per acre. In all cases the content of sulphur in the plants was increased without affecting the content of nitrogen.

The study of the translocation of the mineral matter of plants was continued with corn, beans, and potatoes. A considerable quantity of mineral matter was found to be retained in the cotyledons and tubers during germination, although no marked differences were noted in the retention of the different mineral elements. Some trouble was experienced in deciding on the proper kind of containers for use in this work. Aluminum cups were first tried but later abandoned. Resort was had to paraffin paper cups, which seemed to be more satisfactory. The composition of the cotyledons is being studied to determine the essential plant-food elements for plumule development.

The projects on the occurrence of barium and manganese in plants were carried forward with satisfactory results. The experimental plants were soy beans, cowpeas, alfalfa, corn, wheat, and peach. Various forms of barium were tested. The chlorid and sulphate were found to be toxic, while the nitrate and carbonate of barium either exerted no effect or in some cases were slightly stimulating. The protein content of oats appeared to be somewhat increased as the result of applying barium, but no increase in root-nodule development on legumes was noted. Manganese appears to be located chiefly in heavy seed coats such as peach pits, nuts, etc. Numerous attempts to grow wheat to maturity in the absence of manganese resulted in failure.

Further progress was made in the study of clover bloat. In connection with this work numerous cultures of bacteria and yeasts were made. Additional evidence was obtained confirming a previous finding of the station that clover bloat may be due to the fermentation of carbohydrates by the action of bacteria and yeasts in the clover bloom. It was also shown that the cure of bloat may be quickly effected by administering formaldehyde. The amount of sugar was found to be 3.6 per cent in red-clover blossoms, 2.8 per cent in alfalfa blossoms, and 2.4 per cent in white-clover blossoms.

Work with Hatch and other funds.—The agronomic work for the year included a study of soil fertility with reference to rotations and

tillage, variety tests with cereals and forage crops, breeding experiments with corn and wheat, rotations in connection with tobacco culture, and cultural experiments with cereals, corn, soy beans, tobacco, alfalfa, and Sudan grass. The investigation of soil fertility was carried on at the station and on soil-experiment fields in nine counties representing different types of soil. In the study of tobacco culture it was found that the organic matter remaining in the soil from the previous crop is an important factor in determining the quality of tobacco.

Several lines of work were carried on actively in the field of bacteriology and diseases of live stock. This work included a study of hog cholera, particularly methods of complement fixation and insects as carriers of the disease, malnutrition in hogs, and blackhead in turkeys.

The animal-husbandry investigations for the year involved cooperative experiments with the agronomy department in a study of hog pastures, experiments with self-feeders for hogs, feeding experiments with steers, a comparison of dry lot and pasture for steers, cross-breeding tests with sheep, the use of milking machines, and feeding experiments with poultry. Experiments in hogging down soy beans and cowpeas indicated that this system is not economical. It is found not to be profitable to hog down soy beans unless a supplementary grain ration was fed, and with cowpeas the system was not profitable even with a supplementary grain ration. Some attention was also given to rations for horses and mules with particular reference to a study of the value of silage in horse feeding.

A feeding experiment with poultry involved a comparison of grain mixtures of high and low lysin content. The ration of high-lysin content contained wheat, wheat bran, sunflower seed, hemp seed, and skim milk, while the ration of low-lysin content contained barley, rye, hominy, oats, and gluten flour. Marked differences were observed in the two lots of chickens, the lot receiving the ration of high-lysin content developed the feathers at an earlier age, showed a larger growth, and were more active and vigorous. It was evident that the low-lysin content of the other ration brought about a stunting in the growth of the chicks.

The department of botany and entomology gave much attention to preparation for the work of enforcing the new seed law. This law requires tests of germination in the laboratory. The Hessian fly caused a large amount of damage and a study of the life history of the insect indicated that there is an additional brood in the southeastern part of the State. Considerable work was also done upon a

bacterial disease of sweet corn, bee diseases, and nursery inspection. In experiments with methods of curing blue-grass seeds it was found that these seeds should be gathered when green, preferably between June 15 and June 20, and that care should be exercised to prevent the seed from becoming heated to a temperature above 122° F. Blue-grass seed subjected to a temperature of 140° F. even for a short time are rendered worthless.

The chemical department in addition to performing a large amount of analytical work on soils, rocks, and waters carried on investigations with reference to nitrification in soils, lime requirements of plants, and the mineral contents of the sap of grape and maple. The composition of the sap of these plants was found to vary at different times. It was shown that calcium cyanamid and sodium azoamid are readily nitrified under certain conditions. Studies of Kentucky soils indicated that in the blue-grass region, nitrogen is the only limiting element in the production of profitable crops, while in other sections of the State both phosphorus and nitrogen are limiting elements.

The department of foods and drugs has established a baking laboratory and extensive experiments have been begun on the baking qualities of flour and on methods of making bread. This work includes a study of yeasts and the effects of various amounts of sugar, salt, other ingredients, temperature, and fermentation upon the character of the bread. Analyses were made of a large number of non-alcoholic carbonated beverages. The work of the station in rural economics was confined largely to a study of the marketing of Burley tobacco in central Kentucky. Attention will also be given later to the marketing of eggs and apples.

The following publications were received from this station during the year: Bulletins 189, Commercial Fertilizers; 191, The Teachings of the Kentucky Agricultural Experiment Station Relative to Soil Fertility; 192, Nonalcoholic Carbonated Beverages, Sanitary Condition and Composition; 193, The Soils of Kentucky; 194, Soils of Graves County; 195, Soils of Franklin County; 196, Commercial Fertilizers; 197, The Feeding of Young Chicks on Grain Mixtures of High and Low Lysin Content; 198, The Curing of Blue-grass Seeds as Affecting their Viability; 199, Soil Experiment Fields—A Progress Report; 200, The Locust Borer and Other Insect Enemies of the Black Locust; Circulars 4, Malnutrition in Hogs; 5, A Remedy for Clover Bloat; 6, Inexpensive Appliances and Utensils for the Dairy; 7, Blackhead in Turkeys; 8, Stem Rot of Clovers and Alfalfa as a Cause of "Clover Sickness"; 9, County Agents' Calcimeter; 10, Suggestions Relative to the Prevention of Hog Cholera; 11, Hot Beds and Cold Frames; the Annual Reports for 1912, 1913, and 1914; and the Biennial Report for 1913–1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation-----	71,129.79
Fees, including balance from previous year-----	112,255.30
Farm products-----	49,715.85
Miscellaneous, including balance from previous year-----	702.88
Total-----	263,803.82

The research work of the Kentucky station has been greatly promoted by the intimate personal interest which Director Kastle took in various lines of investigation. His death will be a great loss to the station. The general conditions surrounding the institution are good, and it is making important advances for the welfare of the principal agricultural industries.

LOUISIANA.

- No. 1. Sugar Experiment Station, *Audubon Park, New Orleans.*
- No. 2. State Experiment Station, *Baton Rouge.*
- No. 3. North Louisiana Experiment Station, *Calhoun.*
- No. 4. Rice Experiment Station, *Crowley.*

W. R. DODSON, A. B., B. S., *Director, Baton Rouge.*

The policy and management of the Louisianan stations were essentially the same as in the previous year. Upon the suggestion of the department, in order to concentrate efforts upon the research work in fewer localities, the use of the Federal funds in the support of the North Louisiana station at Calhoun was discontinued. The revenues of the stations for the year, in addition to the Federal funds, were \$17,000 from State funds for general purposes, \$7,000 for the Rice Experiment Station, \$4,000 from fertilizer control, and about \$4,000 from sale of products. All the work of the stations has been placed on a project basis. The experiments previously carried on at the North Louisiana station were continued with the exception of the horticultural work. This part of the work was discontinued with the exception of tests of varieties of grapes and selection of seed potatoes.

C. B. Anders was appointed assistant animal husbandman and R. C. Calloway in charge of the dairy at Baton Rouge. J. B. Garrett, assistant director in charge of the North Louisiana station, was succeeded by C. E. Hester, and E. J. Watson resigned as horticulturist at that station.

Adams fund projects.—The project on cotton and bean anthracnose was completed. The results of this work indicated that the bean

anthracnose fungus (*Colletotrichum lindemuthianum*) develops in several different strains, affecting bean varieties differently. The existence of these strains seems to be correlated with the varieties of beans which do not intergrade nor readily cross. The cotton anthracnose fungus (*Glomerella gossypii*), on the other hand, does not show different strains. The condition is considered as due to the fact that cotton varieties cross readily and that the numerous intergrading forms hinder the development of special strains of the fungus. Cotton varieties appear to show no marked variability in resistance to anthracnose.

The study of cotton wilt was confined largely to a consideration of resistance in different varieties. In continuing the project on eggplant blight, due to *Phyllosticta hortorum*, evidence was obtained that the disease may be carried over in the seed. A supposed perfect stage of the fungus was secured, but inoculation experiments gave negative results. Selection and breeding experiments have been inaugurated and quite successful results were had in controlling the disease by spraying. Much attention was given to the life history of the fungus of tomato wilt. One strain of tomatoes was found to be quite resistant to the disease but the variety is not commercially desirable. A study was also made of the effect of environment on the development of tomato wilt. A new method of selecting for wilt resistance was worked out. The seed bed was sterilized by steam and then inoculated with the wilt organism, which grows rapidly under these conditions. Young tomato plants, developing in these soils, succumb before they are ready to transplant if they are susceptible to the disease.

Troubles experienced in securing a good stand of alfalfa interfered somewhat with the work on alfalfa diseases. A few plats were maintained and notes were taken on the Rhizoctonia disease. Thus far Peruvian alfalfa has proved least subject to an attack of the disease. In continuing work on sugar-cane diseases data were obtained on the effect of different disease organisms on the germination of cane. The red rod fungus (*Colletotrichum falcatum*) seems to be very important in reducing the percentage of germination. Bordeaux mixture proved to be of little avail in controlling red rot. *Thielaviopsis ethaceticus* reappeared in 1915, not having been noted since 1908.

The study of the means by which anthrax is disseminated was continued actively. In this work attention was given to the transmission of anthrax by blood-sucking insects. Anthrax was transmitted from infected guinea pigs to healthy ones by the horn fly. The disease was also transmitted from infected sheep to guinea pigs by the same insect. The anthrax bacilli did not long retain their virulence in the digestive tract of the horn fly. Similar results were

obtained with species of *Tabanus*, although anthrax bacilli were not found in the excrement of flies after feeding on infected blood. The same results were secured with certain species of mosquitoes (*Psorophora janthimosoma* and *Aedes sylvestris*). Studies were continued on bacteria which were found to give a short period of immunity to anthrax. Their identity was not determined. A few experiments were also conducted in immunizing sheep against anthrax.

The nature of cottonseed-meal poisoning was further investigated, attention being given chiefly to an examination of the theories that copperas gives protection when fed with cottonseed meal, and that cottonseed-meal poisoning is analogous to beriberi. Rabbits and guinea pigs fed cottonseed meal died within 18 days with typical symptoms of poisoning, while rabbits and guinea pigs fed rice for 150 days showed no indication of the disease. When copper sulphate was added to cottonseed meal, it was found possible to feed pigs for 118 days without any injurious effects.

The project on injury to corn by rice weevil was completed. Studies were made in mills, warehouses, and breeding cages. Attention was given to the flight of the rice weevil from rice mills to cornfields. Some work was also done on the life history of the lesser grain borer (*Rhizopertha dominica*) and on other insects injurious to rice and rice products, particularly species of *Trilobium* and a cecidomyiid.

The investigation of the efficiency of bagasse as a boiler fuel was continued. A test for hydrocarbons in the flue of a sugar mill gave negative results. It is intended to repeat these experiments during the coming year.

A large amount of work was done on evaporation in sugar manufacture, resulting in the accumulation of a mass of data. Multiple effect evaporators were studied to find a way of utilizing the steam and the incondensable gases in heating the juice before it goes into the evaporators and vacuum pans. Specially devised preheaters were constructed and tested in several mills. The importance of utilizing vapor heating in the evaporation of sugar juice is considered very great in view of the high cost of fuel.

In the bacteriological study of the deterioration of cane sugars efforts were devoted largely to an examination of the factors which influence such deterioration and to a study of the bacterial flora of sugars. Samples were analyzed chemically and bacteriologically at intervals of three months. The limiting factor of deterioration was found to be the ratio between the moisture and the percentage of nonsugars. No deterioration occurs when the moisture does not exceed one-third the percentage of nonsugars. Some evidence was obtained of the associated action of bacteria and torula. Attention

was also given to the influence of certain salts on sugar deterioration and to the effect of small particles of bagasse on the keeping qualities of sugar. The bacterial contamination of sugar appears to come largely from the field. About 19 different organisms have been isolated which are able to withstand the conditions of sugar manufacture. In further study on the organisms in borer-infested cane an alcohol-producing species was isolated.

Little progress was made on the project relating to the effect of red rot on the composition of sugar cane. A study of the molecular rearrangement of reducing sugars with weak alkali was completed. Apparently the rotary power of sugars is not completely destroyed by the action of alkali. The sulphitation process in sugar manufacture received much attention. It was found that the eyes and tops of cane contain polyphenols, which pass into the juice. Mere traces of iron tend to give the juice a dark color. Reducing agents appear to be only temporarily effective in removing the color. The darkening of cane sugar may be prevented if the juice is kept free from iron.

Work with Hatch and other funds.—The principal work conducted under support of Hatch and State funds at the Baton Rouge station was in horticulture, animal husbandry, and agronomy; at Audubon Park, in agronomy; at Calhoun, in agronomy and horticulture; while at Crowley the work was confined to rice investigations. The horticultural work was concerned chiefly with truck crops, cauliflower receiving a large amount of attention. Seed was obtained from various dealers and is being tested for its relative value. The seed grown by certain specialists was found to be twice as valuable as ordinary commercial seed. Similar work is in progress with Brussels' sprouts and broccoli. Strains of broccoli from England, France, and Denmark are under comparative test. Cost accounts are kept of all these operations to determine the profits from vegetable growing. Some work was also done with bell peppers as a summer truck crop.

Experimental plats for grazing work were maintained to study the effect of different feeds on pork and lard. Pigs grazed on sweet potatoes and later fed corn for 10 days produced pork of excellent quality. The use of corn and tankage for 42 days increased the melting point of lard from 38.5° to 44° C. The shrinkage was about the same in pigs on corn and tankage as in those allowed to graze on peanuts. Another feeding experiment with pigs was concerned with a study of mixed forage.

The dairy department conducted an experiment comparing the value of grazing winter oats with feeding silage to Holstein and

Jersey cows. A comparative test of different kinds of silage was also conducted. Soy-bean silage nearly doubled the milk production during the year, proving superior to corn silage. Japanese cane produced 28 tons of silage per acre, but the silage was not quite equal to that from corn or sorghum. The best silage in these experiments was a mixture of corn and soy beans in equal parts.

The field-crop work of the Baton Rouge station included fertilizer tests for corn, soil-renovation experiments with cowpeas, soy beans, and velvet beans, a test of the value of rock phosphate used in connection with lime, and cultural experiments with various crops, including dasheens. The latter crop, although yielding 200 bushels per acre, proved to be unprofitable. Experiments with kudzu bean showed that this plant requires three years to cover the ground.

The veterinary work of the station, aside from the Adams fund investigations, was concerned chiefly with tick eradication and experiments with various dips, including arsenical dips and lime and copperas.

At the North Louisiana station many crop introductions were made leading to improvement of farm practice in the neighborhood of Calhoun. Experiments with grapes resulted very successfully. Satisfactory results were also obtained in experiments in storing sweet potatoes and in grading up native cows with Holstein bulls. The rice investigations at Crowley are wholly supported by State funds and are progressing satisfactorily in cooperation with this department.

The field work at the Audubon Park station included fertilizer experiments in which calcium nitrate and calcium cyanamid were sources of nitrogen. The results of this comparison were not decisive. Experiments conducted for four years with excessive amounts of acid phosphate indicated a decided advantage for the use of large amounts of phosphate. Experiments with *Melilotus indica* as a cover crop were begun. Experiments with seedling canes were continued and nine seedlings have become well established. Preliminary experiments in irrigating cane indicated that the practice is profitable. Two light irrigations, amounting to a total of 3 inches of water, gave an increased yield of about 10 tons of sugar cane.

The following publications were received from this station during the year: Bulletins 154, Protecting Cabbage and Cauliflower from Attacks by Worms; 155, Experiments on Varietal Resistance to the Bean and Cotton Anthracnose Diseases; Feed Stuffs Report for 1913-14; Fertilizer Report for 1913-14; and the Annual Report for 1915.

The income of the stations during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation-----	25,500.00
Fees-----	14,000.00
Farm products-----	4,736.63
Total -----	74,236.63

Some changes were made in the organization of the Louisiana stations, with beneficial results, particularly in the way of concentrating research efforts upon fewer problems and in fewer localities. The work of the stations as a whole moved forward with encouraging success, but there is still need of relieving the director of some of his duties in connection with other agricultural operations.

MAINE.

Maine Agricultural Experiment Station, Orono.

C. D. Woods, Sc. D., *Director.*

The organization, policy, and personnel of the Maine station continued as heretofore without any essential changes. Considerable development took place on the Aroostook farm, where a large amount of experimental work was carried on. The experimental work at this farm and at the Highmoor farm is conducted as an essential feature of the work of the central station. A plan of cooperation between the station and this department was adopted with reference to the study of the nature, causes, means of distribution, and control of potato diseases. In accordance with this plan the department maintains a plant disease laboratory at Presque Isle. Several projects relating to potato diseases are to be carried on cooperatively and the results published with the approval of both parties to the agreement.

Adams fund projects.—The work supported by the Adams fund, as in previous years, was conducted by the departments of biology, entomology, and plant pathology. There is a close connection between the three projects relating to breeding conducted by the department of biology. The work involved breeding oats, beans, corn, poultry, and various phases of inheritance in plants and animals. Experiments with reciprocal crosses between Barred Plymouth Rocks and other breeds of fowls were continued and large additions were made to the data on this subject. In a study of the inheritance of body size and egg characters in poultry about 1,200 chickens were

kept under close observation. Experiments were also made with various substances, such as an extract of the pituitary body, ether, and alcohol, used for the purpose of activating or depressing the ovary of hens. The toxic effects of substances like ether and alcohol on hens were less pronounced than had been expected. Hens which received alcohol in some instances laid more eggs than hens maintained under otherwise similar conditions.

Much attention was given to improving the methods of recording data obtained in breeding experiments. Records secured from breeding work with plants and animals have already reached large proportions. A study of inheritance of milk production by means of progeny records, inbreeding, and line breeding continued to receive much attention. It appears that ordinarily bulls are not kept long enough in herds to show what effect they may ultimately have upon a herd. From the test of continued mating of cousins it was shown that all types of such matings, if continued, lead to values of coefficients of inbreeding approaching 100 per cent. The results of 17 years of breeding for a high egg yield, during which records were kept of nearly 5,000 fowls, showed that for the first few years the general trend of mean production was downward, while as soon as selection was based on a progeny test the general flock averages began to increase.

Oat-breeding experiments included work with varieties, pure-line selections, and hybrid oats. A number of promising hybrid oats have been obtained. It has been found that hard wheat brought from the Northwestern States soon loses its hardness in Aroostook County. Further work was also done in breeding beans and corn, and observations were made on the pollination of apples and upon the effect of top-working Baldwin apple trees.

The output of entomological research has been greatly increased by the employment of a staff of workers from other institutions during the summer season. Seven such investigators were employed during the year. A comprehensive study of the Maine species of leaf hoppers was continued, with special reference to the life history of species which are injuriously abundant in meadows. This work involved the description of old and new species and a careful study of their habits. Apparently rotation is an effective treatment for some of the species of leaf hoppers. In connection with a study of the Psyllidae, attention was given to two stages of *Psylla cerasi*, which infests the bird cherry and to a species which causes galls on *Juncus*.

In continuing work on the economic Diptera in Maine much effort was devoted to a determination of the effectiveness of poisoned bait, especially for fruit flies. The use of poisoned bait was tested in connection with currant fruit fly and apple maggot. *Rhagoletis*

pomonella, which is commonly injurious to the apple, was found to be a pest on the blueberry. It injures only 1 to 2 per cent of the fruit in years when the crop is heavy, but in years of smaller crops 8 to 10 per cent of the fruit may be infested.

The study of plant lice was concerned largely with migratory species with particular reference to their identity and alternate hosts. Attention was given to *Macrosiphum solanifolii* on rose, potatoes, and other plants, *Aphis brevis* on *Crataegus* and clover, *A. cardui* on plums and thistles, and *Schizoneura americana* on the elm and on species of *Prunus*. In connection with this work a key is being prepared for use in identifying species of aphids. *M. solanifolii* is found in the spring on rosebushes, feeding especially near the flower buds, and migration occurs later through both wingless and winged individuals. The migration to potatoes takes place in July. It was found that the woolly aphid of the elm migrates to the Juneberry, where it passes the summer upon the roots of these trees, returning in the fall to the elm to deposit the winter eggs.

Much progress was made in the study of the larval and pupal stages of economic moths. One of the objects of these studies is to determine definitely the characters of moths in their immature stages, in order that they may be accurately identified. The work has involved the comparative study of a large number of cases. Several important species of economic Coleoptera were also under study, particularly flea beetles (*Haltica bimarginata*, *H. ignita*, and *H. carinata*). The first species is injurious to alders, willows, and balsam poplars. Attention is being given to the parasites and other natural enemies which hold these pests in check.

The experiments of the previous year on Rhizoctonia disease of potatoes were repeated and results were obtained confirming the findings which had already been announced. Neither corrosive sublimate nor formaldehyde eliminated the disease but both checked it to some extent, corrosive sublimate being the more effective. Rhizoctonia disease was apparently increased as the result of the use of sulphur.

The experiment in disinfecting seed and soil for the control of powdery scab of potatoes was continued, using corrosive sublimate and formaldehyde on the seed and sulphur in the soil. Infected, contaminated, and clean seed were used in this experiment. All lines of treatment somewhat reduced the disease but none entirely eliminated it when contaminated seed was used. Corrosive sublimate gave the best results as also in Rhizoctonia disease of potatoes. Some beneficial effects were noted with the use of sulphur at the rate of 300 to 1,000 pounds per acre. It appears that the disease spreads readily in the field. Powdery scab was found to attack the tomato as well as the potato.

Some attention was given to mosaic disease, blackleg of potatoes, and other obscure diseases. No evidence was secured that the mosaic disease is of a parasitic nature. Nevertheless it appears to be transmitted through the seed. An apparently new disease of potatoes appeared in Aroostook County and is now under study. There is some indication that the disease is due to plant food deficiency in the soil; possibly the lack of potash. Some progress was made also in the study of blackleg of potatoes, particularly with reference to the thermal death point of the organism which causes the disease. The study of the effect of temperature upon the growth of fungi was confined chiefly to common potato scab. It was found that germination of the organism of potato scab is most rapid between temperatures of 35° and 40.5° C. At a temperature of 10° C. germination required 15 times as long a period as at 35° C. Apparently the minimum temperature for germination is near 5° C. The organism was not killed by exposure to weather below centigrade. While germination of the conidia is most active at 35° to 40° C., these temperatures are unfavorable for long-continued growth. The optimum temperature for growth was found to lie between 25° and 30° C.

Work with Hatch and other funds.—As in previous years, the Hatch and State funds were used largely to supplement various lines of research carried on under the Adams fund. With the support of Hatch and other funds, however, a number of studies were conducted incidental to the experimental work under the Adams funds. This work involves particularly some of the operations carried on at the Aroostook and Highmoor farms. On the Aroostook farm the experiments included tests of acid phosphate versus rock phosphate for oats, commercial varieties of cereals, experiments on the rate of seeding oats, studies of plant food and potash requirements of potatoes, tests of methods of applying fertilizers for potatoes, comparative experiments with sodium nitrate, and ammonium sulphate, and tests of varieties of wheat, buckwheat, and grasses. A grass garden was established in which an effort is being made to obtain improved strains of timothy, other grasses, and clover. Neither potash nor phosphoric acid seemed to be limiting factors in the growth of crops during the years. Further experiments along this line will be conducted. A few rotation systems are also under investigation. Continuing the investigation of crop requirements for potash, particular attention will be given to oats. Further records were obtained in a Jersey sires' futurity test, which is in principle a progeny test begun on a quite elaborate scale in 1915.

In fertilizer experiments with potatoes, heavy applications of potash increased the yield sufficiently to indicate that there may be a need for this fertilizer in the soils of Aroostook County. Sulphate of ammonia appeared to increase the yield of potatoes more than

nitrate of soda and organic nitrogen gave evidence of being less available than either nitrate of soda or sulphate of ammonia. The use of dynamite in preparing soil for planting trees appeared not to decrease the cost of this operation nor to be of benefit upon the growth of the trees. The experiments in rate of seeding oats indicated that the best results may be obtained from the use of 3 or $3\frac{1}{2}$ bushels of seed oats per acre.

On the Highmoor farm much attention was given to apple spraying, fertilizer experiments with apple trees, tests of oat varieties, and the study of the sheep industry. As a general scheme of orchard spraying, the application of lime sulphur in a dilution 20 per cent stronger than the standard formula, at the time of the opening of the buds, followed by arsenate of lead used at the rate of 2 pounds to 50 gallons of water, gave very promising results. Apple-spraying experiments on a large scale have been conducted on the Highmoore farm for the past six years. The results indicated that self-boiled lime-sulphur is nearly as effective as Bordeaux or boiled lime-sulphur. A spray of copper lime-sulphur caused a russetting of more than 57 per cent of the fruit. Extra fine sulphur flour used as a fungicide for scab reduced infected fruit from 12 per cent to about 3 per cent.

A flock of 75 ewes was purchased to study the cost of sheep production. This flock was handled according to the methods of standard farm practice and a careful expense account of the operation was kept. The sheep were in excellent condition throughout the experiment, but according to the data obtained there was a loss of \$257.76 on the operation for the year. The experiment is to be repeated.

The following publications were received from this station during the year: Bulletins 239, Studies on Bean Breeding, I; 241, Woolly Aphid of Elm and Juneberry; 242, Pink and Green Aphid of Potato; 243, Further Data on the Measurement of Inbreeding; 244, Blueberry Insects in Maine; 245, Abstracts of Papers not Included in Bulletins, Finances, Meteorology, Index; 246, Field Experiments in 1915; 247, Report of Jersey Sires' Futurity Test; 248, Studies of Life Histories of Leafhoppers of Maine; 249, Six Years of Experimental Apple Spraying at Highmoor Farm; Official Inspections, 68; Fungicide and Insecticide Inspection; 69, Cream and Milk; 70, Vinegar; 71, Cream and Milk; 72, Feeding Stuffs Inspection; 73, Seed Inspection; 74, Fertilizer Inspection; 75, Fungicide and Insecticide Inspection; 76, Ice Cream—Evaporated Milk; Documents 505, Special Report of the Maine Agricultural Experiment Station for the Commissioner of Agriculture for the year 1914; 510, Suggestions for Breeding Yellow Eye Beans of Standard Types; 514, Experiments at Aroostook Farm in 1915; 515, Methods of Poultry Management at the Maine Agricultural Experiment Station; 518, Cultural Methods with Oats Used

by the Maine Agricultural Experiment Station; 519, Report of Progress on Animal Husbandry Investigations in 1915; and 520, Growing Crops Without Potash in 1916.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	17,171.47
Fees	12,674.52
Farm products	11,141.66
Total	70,987.65

The Maine station has been fortunate in retaining the services of the heads of its various departments through so many years that the continuity of the lines of research has not been broken. All of the experimental work of the station, including that conducted at the Aroostook and Highmoor farms, is directed and supervised by the director of the station and the department heads. This serves to unify and closely focus the research efforts of the station.

MARYLAND.

Maryland Agricultural Experiment Station, College Park.

H. J. PATTERSON, B. S., *Director.*

Few changes either in policy or lines of work occurred at the Maryland station during the year. The State legislature made an appropriation of \$25,000 annually for the next biennial period and \$5,000 for the substation at Ridgely. The legislature at its previous session had appropriated \$30,000 for soil work, \$10,000 to be available for the year ended September, 1915, and \$20,000 for the following year. On account of financial conditions in the State, however, only about \$5,000 of this appropriation became available to the station. Provision was made for an agricultural building through an appropriation of \$174,000. A. G. McCall was engaged to have charge of soil investigations and took up his duties in June, 1916. Arrangements are being made to abandon the plan of assigning men both college and station duties. The present tendency is to separate these lines of work sharply.

Adams fund projects.—The project on metabolic changes in potato tubers involved several phases of investigation, including biochemical studies on the rest period of potatoes, spindly sprout disease, pathological physiology of these tubers, general metabolism of tubers, and mechanism of inhibition and correlations in the growth of buds on the potato tuber. With reference to the little sprout disease it was found that the chief disturbance occurred in the carbohydrates, and attention is being given to a study of the normal processes of the potato with reference to transformation of sugar into starch and vice versa. Cold and oxygen appear to be the two main factors in

these changes. The scientific data established in this study tend to show that the oxidase content in the potato juice gives no indication of the intensity of respiration in the tubers, but that the catalase activity in the potato juice is strikingly correlated with the respiratory activity in the tubers. A beginning was made on the new project of food requirements of plants growing in sand and soil cultures. Suitable laboratory equipment and apparatus have been secured and arrangements were nearly perfected in the greenhouse for the active prosecution of this investigation.

In continuing the study of tomato blight, no success was had in finding a winter stage of the disease, but it was learned that the ordinary septoria is very resistant to cold. Flea beetles and other insects which were studied in this connection seemed not to be important carriers of the disease. Infection is most active when the soil has a medium moisture content rather than when it is excessively wet or dry. The fungus occurs on a number of hosts other than the tomato. A study was also made of the internal action of chemicals with reference to resistance of tomatoes to blight. In a few instances some indication was obtained that concentrations lower than those causing injury reduced the development of the leaf disease. This was particularly true with potassium nitrate, sodium acetate, calcium nitrate, copper sulphate, limewater, sodium tungstate, potassium permanganate, etc. The septoria disease, however, developed normally in the plants which showed actual injury from mercuric chlorid, sodium nitrate, barium nitrate, oxalic acid, and certain other chemicals. On the whole the experiments in which the various chemicals in different concentration were applied to the roots of tomatoes yielded negative results.

The study of Sclerotinia connected with fruit rotting made little progress. Much difficulty was encountered in securing suitable material, especially from the peach. The relation of sulphur and sulphur compounds to cell structure received some further attention. A few trials were made with copper sulphate on tomatoes to determine the curve of the injury or stimulation, but results for the most part were negative. In connection with this work an attempt was made to determine whether mutations or recognizable changes can be produced in plants by the use of excessive amounts of fertilizer. For this purpose dried blood, rock phosphate, and muriate and sulphate of potash were used singly or in complete fertilizer on tomatoes, beans, lettuce, radishes, and potatoes. The results are not yet apparent.

The project on factors which influence hardiness of the peach was carried forward actively. Much attention has been given to a study of suitable methods for conducting the experiment. A series of 144 large cans will be used as containers for dwarf trees in an outdoor

laboratory. Special arrangements have been made for maintaining a constant water supply. The field work involves a study of three varieties of peach trees which are now three years old. About 10 acres, containing 1,122 trees, are devoted to this work.

A new leader was secured to take charge of the investigation of biometric relations in dairy animals. A system was devised for taking measurements, using a standard with movable arms and making about 45 different measurements on each animal. These measurements were made on 29 cows for the purpose of establishing some correlation between conformation or other measurements and milk production.

Some progress was made on the study of yellowing and dying of alfalfa in July and August. Specimens showing typical symptoms of the disease were collected and from them two organisms were isolated. One of these organisms when inoculated into alfalfa grown in the greenhouse produced infection but did not spread to other plants or kill the infected plants. The cause of the trouble is therefore still unknown.

Considerable progress was made in a study of the life history of dipterous leaf miners. The investigation of the life history and habits of the leaf miner of spinach and that of columbine was completed. Some attention was also given to leaf miners of clover, nasturtium, and a number of other plants. The project on diffusion of different forms of lime in the soil was nearly completed, while the project on city milk supplies was largely in abeyance for lack of a leader.

Work with Hatch and other funds.—The work of the station in the field of botany and plant pathology involved experiments with tomato wilt, the continuation of a plant disease survey, and a study of the native grasses of the State. An attempt is being made to develop strains of tomatoes resistant to the wilt and several strains of considerable promise have been produced.

Quite a wide range of experiments was conducted with vegetables and flowers. As a result of three years' experiments with fertilizers on roses in greenhouses, it appears that raw bone is quite as effective as acid rock phosphate or dried blood. Tests were also made with 12 concentrated commercial fertilizers on carnations and chrysanthemums. An experiment is in progress to determine the possibility of improving potatoes by hill selection and to learn the fertilizer requirements for truck lands. In a study of tomato varieties it was found that hand pollination is required for the best results with certain strains. At the Ridgely substation a comparison of commercial fertilizers with stable manure for truck crops was conducted.

Much attention was given to a study of varieties of peaches, cherries, plums, and nuts. Breeding work with apples has been in

progress for a number of years, with the result that more than 1,000 seedling apples, many of them hybrids, are now under observation. A large number of crosses have also been made between Kieffer and other varieties of pears. Breeding work with grapes has been started in which the Delaware variety has been grafted onto other stocks for the purpose of securing a more vigorous growth. The variety work with strawberries was continued, but will be largely transferred to Ridgely.

Some observations were made on the economy of pork production, particularly with reference to home slaughtering. The loss in dressing, the weight of the cooled carcass, and of the various cuts was determined and some experiments were conducted with reference to the feasibility of utilizing waste pieces for sausage, headcheese, etc. The results were not conclusive. In some cases there was a very small margin in favor of home slaughtering.

In the poultry department efforts were devoted largely to a continuation of an experiment to determine whether any vegetable feeds will wholly or in part take the place of commercial meat feeds in a ration for laying hens. A study of the hatchability of eggs as affected by their age was begun in 1911 and has been continued year by year. Records have been obtained on about 30,000 eggs. Further work was done in an attempt to devise a simple farm ration for poultry.

The agronomy work of the station involved a large variety of experiments, chiefly variety tests and improvement work with field corn and sweet corn, and variety tests, selection, and hybridization work with wheat, winter oats, barley, cowpeas, soy beans, and alfalfa. Several of these experiments are carried on in duplicate at the Ridgely substation. Some tests were also in progress in studying fertilizers for grasses and in determining the economic value of Sudan grass for Maryland conditions.

The following publications were received from this station during the year: Bulletins 190, Tests of Varieties of Corn; 191, Relation of Catalase and Oxidases to Respiration in Plants; 192, Internal Action of Chemicals on Resistance of Tomatoes to Leaf Diseases; and the Annual Report for 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation, including balance from previous year	15,669.57
Farm products, including balance from previous year	9,031.71
Miscellaneous, including balance from previous year	1,986.74
Total	56,688.02

The Maryland station continued to be in charge of a combined president and director. This system of organization has been abandoned at all other stations in the interest of efficiency of station management. The provision of regular State appropriations has placed the station on a better financial basis than heretofore.

MASSACHUSETTS.

Massachusetts Agricultural Experiment Station, Amherst.

W. P. BROOKS, Ph. D., *Director.*

The most important building improvement during the year, affecting the work of the station, was the provision of suitable offices and laboratories in the newly completed Stockbridge Hall for the work of the poultry department. Considerable new equipment was purchased and installed for this work. The few changes which occurred in the station staff affected only minor positions with the exception of a change in the botanical department, in which A. V. Osmun became head, while W. E. Stone remained as research physiologist.

The State legislature made an appropriation of \$8,000 to provide for a market garden substation under the control of the trustees of the Massachusetts Agricultural College. It is planned to purchase a location within 20 miles of Boston. The work when definitely organized is to become a regular part of the activities of the station. The revenues of the station derived from State sources were about \$50,000, exclusive of balances carried over from the previous year. The State appropriation was \$5,000 more than for the previous year. A small appropriation was also made for tobacco investigations.

Adams fund projects.—The results obtained from further experiments with fertilizers for cranberries indicated in general that there is no urgent necessity for the use of fertilizers on the better class of cranberry bogs. The work included also a careful analytical study of the chemical nature of the bog waters with particular reference to the determination of colloidal material in these waters. The waters were found to contain some organic matter, iron, phosphoric acid, and a small quantity of calcium carbonate. A beginning was made on the study of the acids of the cranberry fruit.

In the investigation of the use of fertilizers for asparagus it was found that chemical fertilizers are peculiarly adapted to this crop, nitrate of soda, acid phosphate, and muriate of potash giving satisfactory results. The crop yield was uniformly increased where these forms of fertilizer were applied. The maximum profitable applications indicated by the experiments were 450 pounds each of

nitrate of soda and acid phosphate and 262 pounds of muriate of potash. This seems to be the best form in which potash can be applied. No relation was established between the kinds of fertilizer and the amount of rust, but the use of a part of the nitrate of soda near the close of the season, instead of applying it all in the spring, appeared to diminish the tendency to rust.

The project on the chemistry of butter fat was conducted actively. A method was perfected for the determination of stearic acid. Various methods of fat analysis were carefully studied and improvements or modifications of these methods were developed. Considerable attention was also given to the effect of air, light, and moisture on oils and fat. This phase of the project was practically completed.

In continuing the investigation of lime absorption and acidity it appeared that a study of the effects of different fertilizers on the hydrogen ion concentration of the soil solution is an important phase of this work. Some evidence of parallelism was obtained between the lime absorption of soils and the hydrogen ion concentration of the soil extract. With regard to the effect of sulphate and muriate of potash on soils no large difference in the effects of these two potash salts on the lime content of soils was noted. The work was undertaken to determine the cause of the difference in growth of certain crops on muriate and sulphate plats. Determinations were made of potash, lime, and magnesia in the soil. While the differences were not great the total lime was consistently less in the sulphate plats and the average quality of available lime was also lower in these plats. There were also indications of slight differences in the acidity of the soil solutions and the formation of a more slowly hydrolyzing salt as the result of the use of sulphate of potash.

The study of the solvent effect of ammonium sulphate on soil was completed. The results obtained during the year were confirmatory of those previously secured. It was shown that a liberal use of lime was required to render available the nitrogen of ammonium sulphate. The absorption of ammonia from sulphate of ammonia solutions by the soils increased with the increase in the concentration of the solution. The absorption of dyes by these soils was similar to that of ammonia, more dye being absorbed from the more concentrated solution. Ammonium sulphate appears to exercise a solvent action on the calcium in the soils but not on the sodium or potassium in the presence of sufficient quantities of lime. The use of ammonium sulphate seems not to cause the accumulation of sulphates in the soil.

The project on plant breeding in so far as peas and beans are concerned was brought to a conclusion. Attention is now being given to a selection of squashes in an effort to secure a homozygous race. Thus far the results have not been promising. Work was continued

on the study of the interrelation of stock and scion in apples. The orchard used for this purpose consists of 1,100 trees of 6 varieties on 14 root varieties. About 2,000 trees have also been propagated on known roots in the nursery. Comparative tests with reference to rooting ability are being conducted on 129 varieties of apples. Incidentally data are also being collected on the behavior of crown gall on different varieties of apples.

The investigation of conditions under which arsenicals burn foliage was continued with satisfactory results. More than 300 spraying materials have been applied under varying conditions. The experiments thus far have been conducted with chemically pure materials. Some tests with commercial spray materials will be made for the purpose of comparison. The investigation of the habits of digger wasps in relation to agriculture was concerned largely with the classification of these wasps with particular emphasis upon their economic importance and upon the occurrence and distribution of the wasps.

Considerable progress was made upon the study of the life history of cranberry insects. During the year much attention was paid to parasites of the cranberry fruit worm. Several new species have been discovered. Evidence was obtained that parasites were an important agency in holding the fruit worms in check. An effort is being made to increase the natural effectiveness of the parasites by harboring them during the winter. Some work was also done on gipsy moth, cranberry tip worm, black-head fireworm, and a span-worm (*Abbotana clemataria*.)

A study of optimum conditions of light for plant response indicated that the intensity of light which gives the maximum production of fresh and dry matter varies with the stage of development of the plant. Much attention was devoted to devising more accurate methods of measuring light intensity. It is hoped that by this means the change in light requirements at different stages of growth in plants can be definitely determined for important greenhouse crops. The physiological reaction of plants to light intensity is under study with reference to the regulation of gaseous exchange between the plant and environment. A large amount of data has been gathered concerning the action of stomata under varying conditions of temperature and moisture. A device was constructed permitting direct microscopic observation of stomata on the living plant.

Work on the mosaic disease of tobacco was practically completed. The results indicate that the disease is not of parasitic origin, but is caused by unsuitable conditions in the seed bed. A beginning was also made on the study of a new tobacco disease of unknown origin.

The investigation of bacillary white diarrhea was confined largely to efforts to simplify and determine the specificity of the agglutinin test and the age at which the test is reliable. It appears not to be reliable for pullets under 1 year of age. Use of the test on more than 9,000 fowls in different flocks indicated that about 12 per cent of the fowls in the State are infected. Disease occurs in young chicks and in laying hens, sometimes affecting 50 per cent of the flock. Infection is transmitted through eggs, day-old chicks, and mature stock. With the application of the blood test and the elimination of reacting fowls a marked lowering of infection in the flock is noted.

Some progress was made in the study of foul brood with regard to accurate diagnosis, preventive treatment, control, and the means of transmission of the disease. The results indicate that the queen bee is one means by which the disease is disseminated. The relation of *Bacillus lanceolatus* to foul brood was also studied.

The subject of broodiness in poultry was pursued with considerable success. Good results were obtained in breeding for a nonbroody strain of Rhode Island Red fowls. Matings of one male with nonbroody hens gave only nonbroody pullets. A statistical study of broodiness is under way. In four instances ovaries from the broody race were transplanted into pullets belonging to a nonbroody race. These cases will receive further attention. Some progress was also made in the study of the organic matter of soils as related to fertility. The work was concerned largely with the available energy of organic matter, decomposition of organic matter by soil bacteria, and total organic matter in soil of certain selected plats.

Work with Hatch and other funds.—The department of agricultural economics made an investigation of methods and cost of distribution of onions in the Connecticut Valley. Similar studies will be made on tobacco.

The agronomic work of the station included the study of the use of lime and sulphate of ammonia on onions, basic-slag meal and potash in top-dressing grass lands, the comparison of common alfalfa and the Grimm variety, and experiments with different forms of phosphates. The improvement of aeration by admixture of sand, lime, and organic matter seemed to increase the availability of potash. Large yields of hay were obtained on plats previously fertilized without the additional application of basic slag or potash. Corn reached maturity sooner on plats on which manure had been piled during the winter. Common alfalfa gave better results than the Grimm variety.

The department of vegetable physiology and pathology investigated blister rust on white pine, rust on *Antirrhinum*, and rot of

stored onions. The work on white-pine blister rust was largely confined to field observations. The morphology and life history of the rust fungus of *Antirrhinum* were carefully studied and notes were taken on the relative susceptibility of different varieties.

The chemical department studied the digestibility of vegetable ivory meal, conducted digestion experiments with sheep, and carried on a comparative experiment with alfalfa and timothy hay as a source of milk protein. Some work was also done on methods of analyzing lime-sulphur and on milk substitutes for rearing dairy calves. With one lot of 10 calves fed for 235 days on a small amount of whole milk, liberal amounts of skim milk, and mixtures of ordinary grains, the average daily gain was 1.22 pounds, made at a cost of 7.7 cents. Another lot of 48 calves fed on whole milk with proprietary calf meals made an average daily gain of 1.17 pounds at a cost of 9 cents a pound. It appears that from the standpoint of economy as small an amount of milk should be used as is consistent with the satisfactory growth of the calf. Vegetable-ivory meal was found to contain 75 per cent of nitrogen-free extract, chiefly mannan. Sheep ate the meal readily when mixed with grains and it was quite completely digested. In rations for cows the meal appeared to show some value as a productive feed. Digestibility experiments with sheep involved the use of gluten meal, distillers' grains, corn, bran, tankage, feterita, and sweet clover. The protein of alfalfa was shown to be as readily assimilated as that of timothy and gluten products.

At the cranberry substation the usual meteorological observations were recorded and some experiments were begun in methods of frost protection. Tests in resanding the cranberry bog were undertaken to determine the effects of insect pests, growth of the cranberry bushes, and keeping quality of fruit. Some attention was also given to cultural requirements of cranberries. Work has been planned on the improvement of cranberries by selection and crossing.

The entomological department studied the life history of codling moth and methods of controlling onion maggot and red spider, and made observations on scale insects and other pests. It appears that the second brood of codling moth, if it occurs at all in the State, is not of practical importance. No satisfactory method of controlling the onion maggot has been found. The high cost of proprietary sprays to be used for red spiders in greenhouses led to laboratory experiments with spray materials which promise a satisfactory outcome. The apicultural work of the station included the keeping of records on the wintering of bees, wintering queens in nuclei, and experiments with various methods for the extraction of wax from old combs.

The horticultural department conducted experiments in orchard management, cover crops, methods of pruning, tests of nursery stock, variety tests, and observations on apple growing in Franklin County.

The meteorological department continued its detailed records.

The department of microbiology studied the relation of hydrogen ion concentration of media to the proteolytic activity of *Bacillus subtilis* and *Streptococcus erysipelatis*. It was found that certain hydrogen ion concentrations measure the exact influence, both inhibitory and prohibitory, and indicate the exact limits of the proteolytic activity of *B. subtilis*.

The poultry department continued its breeding work for high winter-egg production. One small family of fowls, producing eggs of superior hatching quality, has been secured, and distinct negative correlation was determined between the weight and the age of pullets at the time of the first egg. It appears that the heavier the pullets the poorer the egg production. Some observations were made on preferences of fowls for certain foods. A pronounced distaste was noted in the case of alfalfa and linseed meal. The veterinary department made observations on the length of time during which immunity to hog cholera inherited from an immune dam persists. It was shown that such immunity does persist for a considerable length of time. The inspection of fertilizers and feeds, as in previous years, involved a large amount of work.

The following publications were received from this station during the year: Bulletins 162, Phosphates in Massachusetts Agriculture—Importance, Selection, and Use; 163, Bacillary White Diarrhea in Young Chicks in Massachusetts; 164, Substitutes for Milk in the Rearing of Dairy Calves—The Cost of Rearing a Dairy Cow; 165, The Effect of Sulphate of Ammonia on Soil; 166, Improved Methods for Fat Analysis; 167, The Relation of Hydrogen Ion Concentration of Media to the Proteolytic Activity of *Bacillus subtilis*—Proteolysis of *Streptococcus erysipelatis* and *S. lacticus* Compared Under Different Hydrogen Ion Concentration; Bulletins 3, Control Series, Inspection of Commercial Feedstuffs; 4, Inspection of Commercial Fertilizers; Meterological Bulletins 318-329; Circulars 55, Green Manuring and Cover Crops; 56, Campaign to Eliminate Bacillary White Diarrhea; 57, Rules Relative to Testing Dairy Cows; 58, The Feeding Value of Apple Pomace; 59, The Use of Fertilizers in 1916; 60, Suggestions for the Use of Fertilizers for Tobacco and Onions for 1916; 61, Cutworms; 62, Beet Residues for Farm Stock; 63, Balanced Rations for Dairy Stock; and the Annual Report for 1915, parts 1 and 2.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation, including balance from previous year -----	51,778.19
Fees -----	9,933.75
Farm products -----	7,748.37
Miscellaneous -----	11,309.94
Total -----	110,770.25

The Massachusetts station is making important contributions to the knowledge of a large number of urgent agricultural problems. Its work is practical, resting on a sound basis of investigation. It is becoming a more and more important factor in the agricultural development of the State.

MICHIGAN.

Experiment Station of Michigan State Agricultural College, *East Lansing*.

R. S. SHAW, B. S. A., *Director*.

The work of the experiment station suffered somewhat during the year from a loss of State funds, due to a readjustment made necessary by the destruction of the engineering building by fire. The State funds available to the station for the year amounted to nearly \$42,000. From the general funds at the disposal of the college the station is provided with buildings, laboratories, water, light, and heat. The station publications are also published at the expense of State funds. The two substations are maintained entirely on State funds, South Haven receiving \$2,000 to \$3,000, and Upper Peninsula substation from \$8,000 to \$9,000 annually. F. S. Kedzie was elected president of the institution, succeeding J. L. Snyder.

Adams fund projects.—The effect produced on milk by diseases in the cow was studied with special reference to abortion. The agglutination test was tried as a means of determining the presence of the abortion bacillus in milk. It was found that when a pure culture of this organism was introduced into the milk cistern of a cow's udder the corresponding agglutinins soon appeared. In every case in which abortion bacillus was demonstrated in the milk by means of animal inoculation the agglutinins for this organism were also found. The agglutination test appears, therefore, to be of considerable value in determining the presence of *Bacillus abortus* in milk.

In continuing the study of the keeping qualities of butter further attention was given to factors which influence the resistance of bacteria in cream, the ripening of cream, pasteurization and its influence,

and the bacterial flora of butter. The results obtained in the study of the factors influencing the resistance of bacteria in cream have been prepared for publication.

The soil solution in relation to soil bacteria was studied with particular reference to the development of better methods of measuring the biological processes in the soil. The physical, chemical, and biological aspects of the soil solution received careful attention. Thus far special stress has been laid upon nitrogen, but the phosphorus and potash content of the soil solution will also be studied. In a study of the effects of certain acids, alkalies, and organic salts in the soil solution it was found that bacteria developed best when the reaction was $\frac{N}{1,000}$ alkali. A reaction of $\frac{N}{1,200}$ acid killed 98 per cent of the bacteria in the solutions under test. An acid reaction of $\frac{N}{2,860}$ prevented the growth of about one-half of the bacteria in the soil solution.

Little progress was made in the study of swine epidemics on account of changes in leadership. An attempt is being made to develop a satisfactory laboratory method of diagnosis. With this end in view it is proposed to make a careful study of hog-cholera serum and vaccines, including also an investigation of complement fixation.

Progress in the study of contagious abortion was recorded. An attempt is now being made to determine carefully the bacterial flora of the reproductive organs. In cysts occurring in the ovaries an organism resembling that of abortion was found, but no antibodies could be determined.

The study of the factors which influence soil temperature and the effect of soil temperature on physical processes in the soil was completed. The physical investigation of soil will now be concerned with a study of the freezing point as a means of measuring the concentration of the soil solution directly in the soil. It has been found that the factors nearly always responsible for differences in soil temperatures are latent heat of fusion of ice, latent heat of evaporation of water, covering of the soil surface, color, and topographic position. In general it appears that little artificial control can be exercised over the influence of soil temperature under field conditions. With reference to the new phase of physical studies on soils, the freezing-point method was taken as a means of measuring the actual concentration of the soil solution. It was found easy to determine the freezing point in soils. The freezing point of different soils was determined at a high and low moisture content. At a high moisture content the freezing point of different soils was lowered only slightly, but at a low moisture content the freezing point may be lowered greatly with a concentration of the soil solution,

particularly in clay soils. In all soils, with the exception of very sandy soils, the ratio of the lowering of the freezing point is not directly inversely proportional to the ratio of the water content, but many times greater than the latter.

In continuing the project on adsorption in relation to soluble fertilizer salts it was found that when a soil or kaolin is treated with salt solutions of varying concentrations, the results indicate that the action is one of adsorption and not of double decomposition. Soils which had adsorbed large quantities of potassium were found to give up large quantities of this element when treated with certain salt solutions. This investigation is supposed to be connected with the study of adsorption in relation to osmosis in soils. The preliminary results obtained in this study have been prepared for publication.

The organic nitrogenous compounds of peat soils received considerable attention during the year and the project was practically completed. The quantities and forms of nitrogen in peat were studied with particular reference to the relation between chemical composition and the availability of nitrogen. Various nitrogenous materials, including organic ammoniates, were compared with peat with reference to nitrogen availability. Some of the results of this study have been prepared for publication, particularly the results obtained from composting peat with other material and on the study of nitrogen from the drainage water of soils treated with organic material, including peat and manure.

The study of adsorption of solutes by plants, with special reference to balanced solutions, indicated that when solutes are added to solutions to maintain an equilibrium, seedlings grown in such solutions made the best growth. In this work 36 combinations were tested, and while one particular ratio seemed to give the best results, it is believed that there may be more than one which will produce satisfactory effects.

A study of the nature of the toxic effect of insecticides was practically completed. Attention was also given to the factors which govern mating in the honeybee. The mating position of the queen was observed perhaps for the first time.

The investigation of a limb and twig disease of fruit trees was nearly completed. It has been found that the organism used in inoculation work loses its virulence within one or two years. Fairly satisfactory methods of controlling this disease have been devised.

Work with Hatch and other funds.—The bacteriological department made a study of white diarrhea of chickens in which complement fixation was used successfully in diagnosis. The use of the complement fixation test as a means of diagnosing roup, however, did not give satisfactory results. Some work was done on hemorrhagic

septicemia, nodule organisms of legumes, fermentation of vinegar, bacteriology of milk and of water.

The dairy husbandry work was concerned chiefly with a study of methods of manufacturing dairy products and on the cost of producing milk for condensaries. In collecting data for this study records were obtained on 75 farms.

A large amount of experimental work was conducted by the department of farm crops. This work included a continuation of rotation experiments with fertilizers and manures, breeding experiments with alfalfa and cereals, and variety and cultural tests. The plats selected for rotation experiments proved more acid than was anticipated and were limed to correct this condition. The results thus far obtained indicate a value of \$6 a ton for barnyard manure when reinforced with commercial fertilizers. Some promising varieties of corn were sent out for testing on a large scale by cooperating farmers. Much difference in hardiness, type, yield, and other characters was found in individual plants of alfalfa. An attempt is therefore being made to develop certain strains for particular purposes. Similar work is under way with wheat, barley, oats, and other plants. Several thousand bushels of pedigreed seed produced in the course of these breeding experiments have been distributed for further testing. It has been found that late plantings of winter barley do not give satisfactory results. The best yields are obtained from planting between September 5 and October 5. Considerable attention has also been given to the improvement of timothy and beans by breeding. A strain of beans has been obtained giving a three-year average of 35 bushels per acre. The value and adaptability of hairy vetch to Michigan conditions are also being investigated.

The horticultural department devoted its efforts to the study of the effect of dust sprays, preservation of small fruit by freezing, spraying and fertilizer experiments with potatoes, performance records of apple varieties, thinning experiments with apples, and methods of renovating old vineyards. The results obtained from dust sprays in two large orchards were not promising. The quality of small fruits was found to be preserved in a satisfactory condition when frozen solid. A heavy frost interfered with the year's work in thinning apples. A general study was made of a suitable program for spraying orchards in ordinary practice.

The botanical department is studying the anthracnose and bacterial blight of beans and diseases of celery and cucumbers. Beans grown in Michigan were sent to Idaho to be grown in a dry climate and returned to Michigan for further testing. Seed obtained from Idaho showed little advantage over seed grown in Michigan on ac-

count of the prevalence of an unusually dry season. The seed obtained from Idaho, however, was free from anthracnose. In the study of celery diseases particular attention has been given to a bacterial disease. Fungicides proved ineffective in controlling this disease, but good results were obtained from steaming the soil. Several resistant plants have been found among the better varieties of celery, and an attempt will be made to breed a strain of satisfactory resistance. Considerable work was also done on cucumber diseases in cooperation with this department. It appears that the mosaic disease of cucumbers is similar to that of tobacco and that it can be readily carried by insects and transmitted in the juice of infected cucumbers. In experiments with methods of controlling the root-rot nematode, steaming the soil for 30 minutes gave satisfactory results, the nematodes being quite exterminated from the soil by steam sterilization. Some attention was also given to ginseng disease and to the Septoria disease of celery. It appears that this disease may be controlled by disinfecting the seed in a corrosive sublimate solution before planting and by spraying at intervals of two or three weeks with Bordeaux mixture.

The forestry work of the station was carried on chiefly under support of State funds. During the year attention was given particularly to the culture of willows for basket making. Only about 5 per cent of the willow cuttings thus far planted have died. The interest of furniture manufacturers has been enlisted and the station is making a study of the economic aspects of basket-willow culture. A study is also being made of shade trees for farm yards and highway planting and of maple-sugar production.

The chemical department has charge of feed-control work according to State law. A study is also being made of the cause of disintegration of cement tile, losses and methods of preserving barnyard manure, and analyses of insecticides and fungicides. Data are being accumulated in connection with soil analyses bearing on the question whether correlations occur indicating the relative agricultural value of soils. The department also cooperated with the horticultural and other investigational work of the station.

The animal-husbandry department conducted feeding experiments with hogs, sheep, steers, horses, and poultry. In pig feeding an attempt is being made to determine the value of supplementing concentrates with pasture. The effect of succulent feeds on mutton and wool are also being studied in sheep-feeding experiments. The use of succulent feeds has thus far given very promising results. In steer-feeding tests, cottonseed meal and raw, ground, and cooked beans were prepared. Some feeding experiments with steers were also conducted at the Upper Peninsula substation. The value of silage is

being tested in horse rations. The poultry work of the station also includes a comparative test of various rations and a study of the cost of egg production.

The entomological department is making a study of injury to peaches from an unknown but presumably insect cause. No conclusive results have been reached. Some attention was also given to testing the value of different substances and methods of insulating double-walled beehives for wintering bees. The results obtained from the propagation of parasites of the tamarack sawfly were not promising. A study was also made of the bean maggot and methods of transferring bees from one locality to another.

The soils department conducted experiments on county farms mainly with reference to fertilizers and rotations. Chemical analyses were made of samples of the soil from some of these farms. A system of green manuring has been instituted at the station to ascertain the relative cost of nitrogen secured from legumes and from commercial sources.

The following publications were received from this station during the year: Bulletin 275, Fertilizer Analyses; Special Bulletins 72, Some Ginseng Troubles; 73, Spray and Practice Outline for 1915; 74, Analyses of Some Materials Sold as Insecticides and Fungicides; 75, Durability of Concrete Drain Tile; 76, Transferring Bees; 77, The Septoria Leaf-spot Disease of Celery or Celery Blight; Technical Bulletins 20, Experiments on the Control of the Root-knot Nematode; 21, How Contact Insecticides Kill, III; 22, Effect of Temperature on Some of the Most Important Physical Processes in Soils; 23, A Simplified Apparatus for Measuring the Conductivity of Electrolytes; 24, The Freezing Point Method as a New Means of Measuring the Concentration of the Soil Solution Directly in the Soil; 26, Soil Temperature; Circulars 25, The Composition and Value of Farm Manures; 26, Losses and Preservation of Barnyard Manure; 27, Hairy Vetch; 28, The Bean Maggot in 1915; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	27,405.00
Fees	14,545.00
Miscellaneous, including balance from previous year	6,706.75
Total	78,656.75

The Michigan station has a strong following among the farmers and business men of the State, and is in position to make an even larger place for itself in the development of Michigan agriculture.



FIG. 1.—PATHOLOGICAL LABORATORY, ISOLATION BUILDINGS AT LEFT, MINNESOTA STATION.

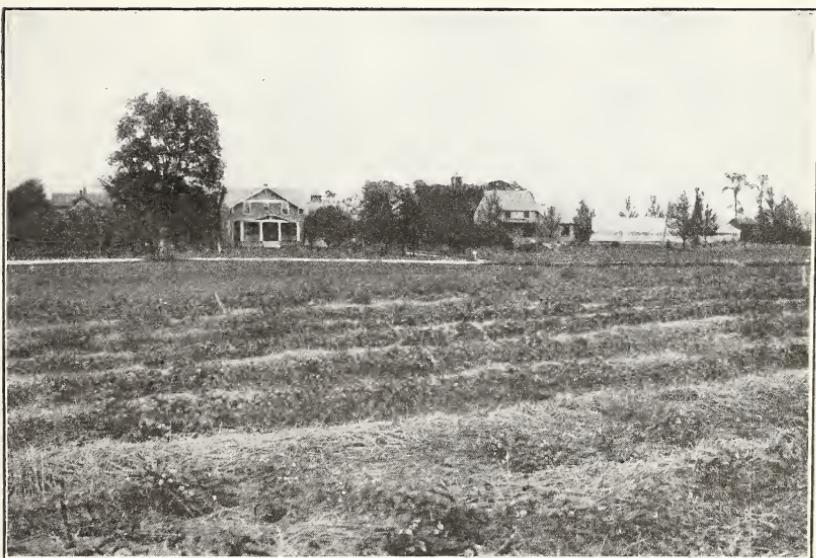


FIG. 2.—FRUIT-BREEDING FARM, ZUMBRA HEIGHTS, MINNESOTA STATION.

MINNESOTA.

Agricultural Experiment Station of the University of Minnesota, *University Farm, St. Paul.*

A. F. Woods, M. A., *Director.*

The station has worked out a new plan of organization designed to group the various lines of work more logically and harmoniously. The plan is to arrange in groups the lines of work which are most intimately connected and to appoint a chairman for each group from year to year according to special fitness for the position. The new plan of organization will go into effect during the fiscal year 1916-17. Dr. C. W. Gay was appointed as head of the animal industry division and chairman of the group of animal industry, and Prof. H. H. Kildee in charge of the dairy husbandry division, both to assume their duties after the close of the fiscal year. Prof. R. W. Thatcher was appointed assistant director and will have immediate supervision of the problems concerned in coordinating the research work of the station as a whole. Dr. H. P. Hoskins and J. T. E. Dinwoodie, who had been connected with the manufacture of hog-cholera serum, resigned. A research laboratory in animal pathology was completed (Pl III, fig. 1) and an additional greenhouse was erected at the fruit farm.

Adams fund projects.—The project on rust of cereals includes a study of resistant hybrids and of grass rusts as connected with the infection of cereals. A survey was made to learn the species of grasses infected with *Puccinia graminis* and to determine the most susceptible species. Numerous cross inoculations were made, using various forms of grass rusts and transferring them from one host to another. The evidence thus obtained indicates that biological forms of rusts are true species. A large series of hybrid wheats have been obtained which are quite resistant to rusts but are for the most part inferior in milling quality. By means of artificial inoculations timothy was infected with *P. graminis avenae*. Timothy exerted an appreciable effect on the morphology of spores of this rust, reducing them in size and in virulence. The presence in the soil of excessive or deficient amounts of plant-food elements did not affect the severity of rust infection. A few resistant hybrids have been obtained with good milling qualities.

The study of heredity in connection with disease and climatic resistance of the apple, plum, and strawberry was continued (Pl. III, fig. 2). Numerous crosses were made between native and Japanese plums. These hybrids proved not to be particularly hardy. Crosses have been obtained between wild and cultured strawberries. The effect of allowing strawberry plants to become thoroughly dried out in the fall is under observation. The factors of hardiness which are

receiving attention include sap density, wood structure, and various chemical and cytological matters. A study is also being made of sterility as related to hardiness. In the plum pollen sterility was noted, especially in hybrids. The hereditary relations of sterility are under investigation. Twigs of four varieties of apples were collected at intervals during the year and their water content determined with reference to its bearing upon hardiness.

In continuing the study of glacial drift soils it was found that methods for determining phosphoric acid are somewhat unreliable and a method was devised in which the technical accuracy was improved. Carbon, organic matter, lime, and potash are determined in the drift soils. The problem under study is whether the age of the drift soils is correlated with their composition as a result of leaching. It appears that lime is leached out to a depth of 3 feet in old drift soils but no other striking differences were noted.

The project on the movement of water in the soils was carried forward actively. This work is done largely in cylinders which are allowed to stand for several months before moisture determinations are made. The results are also checked by similar experiments under field conditions. All physical constants of soils are determined before using them in the investigation. An attempt is being made to determine whether there is any correlation between the physical constants of the soil and the movement of water. There seems to be a definite relation between the moisture movements and the hygroscopic coefficient of soils. The effect of considerable quantities of organic matter is to give the ratio of the moisture equivalent to the hygroscopic coefficient a higher value.

The study of the strength of wheat flour received careful attention. The work began as a study of enzymes, physical constants, and characteristics of the protein of wheat. During the year attention was given to peroxidases in flour as a means of classifying flour grades. The amount of oxygen liberated from hydrogen peroxid in contact with flour for 15 minutes was found to be perhaps the best means of measuring the baking strength of flour. Starch-splitting enzymes were also investigated. A group of enzymes was found which split the envelop of the starch granule, thus exposing the starch grains to the true starch-splittingenzmys. Further studies will be made of the effect of electrolytes on the physical properties of the wheat kernel. A new method for measuring the expansive power of dough as an indication of the strength of flour was perfected.

In the project on the chemistry of resistance to disease in plants, some wheat plants were stripped at flowering time and later carefully studied with reference to their chemical composition at weekly intervals. It was found that photosynthesis is fully as active in the stems as in the leaves and that nearly as much carbohydrate mate-

rial is developed in leafless stems as in normal stems bearing a full complement of leaves. It is believed, therefore, that the important photosynthetic power of the wheat stem is the main reason why stem rust causes so serious injury to the wheat plant. Incidentally it was found that rust infection causes a great increase in respiration in wheat plants. It was found that the most hypersensitive wheat plants are most resistant for the reason that rust fungus immediately kills the tissue at the focus of infection and then dies.

Further progress was made in the study of the food requirements for the rearing of stock and for meat production. During the year two steers were slaughtered and an elaborate series of analytical data was obtained from these steers, and also from eight other animals previously slaughtered. These data include weight percentages of various parts from animals varying in weight from 100 to 1,500 pounds. It is expected that the analyses in connection with other data will show the food requirement for production.

Some interesting results were obtained in the study of the specific toxicity of various chemicals to insects and their hosts. Attention was given particularly to house flies, bluebottle flies, and a few other related species. It was found that nitrobenzene kills house flies much more quickly than bluebottle flies. Similar tests are being made with benzaldehyde, xylene, phenylhydrazin, toluol, cresols, phenols, carbon bisulphid, hydrocyanic-acid gas, and other substances. In a comparison of the toxicity of various benzene compounds it was found that the ortho-benzene compounds are most poisonous toward insects and the para-benzene compounds least poisonous. The inverse order of toxicity was noted regarding plants. The germination of corn appeared to be decidedly stimulated by fumigation with nitrobenzene. In fumigating greenhouses with hydrocyanic-acid gas, photosynthesis in tomatoes was temporarily checked but later was greatly stimulated, thus leading to a large increase in the amount of fruit.

Work with Hatch and other funds.—The soils division conducted a study of peat at the university farm and at Grand Rapids substation in both the field and greenhouses. The work involved a determination of the chemical composition and physical properties of peat. It was found that frost occurs more frequently on peat than on mineral soils. Lime applications invariably benefited the growth of clover. Numerous fertilizer experiments are in progress at the main station, Grand Rapids, and Crookston. A general study of the lime requirement of Minnesota soils has been begun. On the university farm lime showed no benefit on alfalfa although the soil is decidedly acid.

The division of agricultural chemistry is studying the influence of environment on the composition of wheat in an attempt to deter-

mine the specific effects of various environmental factors. The long-continued study of the manufacture of sorghum sirup has been nearly completed. It was found that the use of silicious earth as filter material serves to remove the objectionable color and offensive flavor from the sirup. Work was also done on the effect of the moisture content of sirup upon its keeping qualities, upon the effect of climate upon the development of hydrocyanic acid in sorghum, and upon methods of manufacturing cider and vinegar from apples.

The division of plant pathology and botany carried on a wide range of experiments, including studies on flax rust, flax wilt, fungi imperfecti on cereals, rye smut, septoria disease of tomatoes, and various fruit diseases. It was shown that the spores of corn smut are killed in silos within three weeks. The study of flax rust and flax wilt is carried on in cooperation with the division of plant breeding. An attempt is being made to determine whether resistance is a mutation or a character brought out by crossing or straight selection. In the study of fungi imperfecti on cereal roots particular attention was given to wheat scab. A prolonged hot-water treatment, proved quite effective in controlling loose smut. A study is also being carried on with reference to varietal resistance of plums to brown rot. It appears that chemical differences in composition account for the variations in resistance. Spraying experiments were also conducted for the control of apple scab, black rot, raspberry yellows, and various other insect and fungus diseases. The plum pocket disease was largely controlled by spraying with lime-sulphur or Bordeaux mixture. In the seed laboratory studies are being conducted on the vitality of seeds in the manure of various animals and also on lawn-grass mixtures. A comparative experiment is also in progress on the relative effects of freezing, drying, and scarifying hard legume seeds.

The work of the division of horticulture is largely along the line of breeding and selection of beans, onions, squash, tomatoes, potatoes, and apples. By means of pure-line selection certain strains of beans and peas seem to have been fixed. A late-sprouting onion of good keeping quality has been secured by breeding. In a study of first-generation hybrid tomatoes it was found that earliness may easily be combined with smoothness in the tomato fruit. The yield of first-generation hybrids was from 2 to 5 tons more fruit than that of the parents. A study is also being made of senility of certain strains of potatoes with reference to the effect of shade, moisture, and other factors. The transfer of seed from the university farm to Morehead or Grand Rapids and its return after a generation or two appears to be beneficial. The cause of the senility is not yet understood. In pruning apples it was found that summer pruning must be light or merely enough to hold the symmetrical form of the tree; otherwise

the tree is injured. Blueberry culture is also receiving attention in the northern part of the State.

The division of agronomy and farm management conducted a large variety of work, including breeding of cereals, flax, millets, and clover; a comparison of heavy and light seed in oats and wheat; a study of Sudan grass, sweet clover, corn culture, fertilizer experiments, and cost accounting. An attempt is being made to develop hardy strains of wheat. Considerable success has been had with about 25 strains. In comparing the results from heavy and light seed with oats, heavy seed showed an advantage in case of early oats. Fall and early spring plowing of spring wheat proved to be equally good. It was shown that short rotations give better opportunity than long ones for the control of quack grass. This weed was effectively controlled by growing fodder corn or buckwheat for three successive years on the same land. In a study of various systems of cultivating corn a larger net profit was found from six than from four cultivations. It was also shown that not only the number but also the percentage of barren stalks increases as the number of stalks per hill increases. A detailed study was made of the cost of producing sugar beets, and also of cultural methods for the growth of tobacco. Records have also been obtained on the labor requirements of live stock and on the cost of producing sweet corn and other vegetables.

The veterinary division devoted considerable effort to the study of laboratory methods for diagnosing swamp fever in horses. Some attention was also given to the immunization of cattle against contagious abortion. The hog-cholera work included a histological study of diseased tissue, the attenuation of hog-cholera virus, a study of the bacterial flora of various sera, and of blood elements in health and in cases of hog cholera. An investigation of the physiology and histology of the hog's blood was continued actively. Some attention was also given to cretinism in hogs in which the thyroid gland appears to be of large importance. In connection with a study of tuberculosis in cattle it was found that the saliva of the ox contains a starch-splitting enzym different from that of human saliva, with a thermal death point of 65° C.

The entomological and zoological work of the station involved a study of white-pine blister rust as related to insect attacks, the life history of mice, and observations on various economic insects. Bacterial cultures gave no positive results in the eradication of mice. A systematic study of the Hymenoptera of the State was brought to a close. In attempting to find a substance which would repel bees from poisonous sprays some success was had with tannic acid and ammonium carbonate. A study of the life history of the oak-twig girdler showed this insect to have a two-year life cycle. The control

of the strawberry weevil was found to be a relatively easy matter on account of the fact that the weevil passes the winter under the old leaves in the berry fields. Some further work has been done on the artificial impregnation of bees. Nine queens were thus inseminated without results.

The division of agricultural economics is laying special emphasis on a study of plans for the utilization of waste land in the northern part of the State. The division cooperates with the division of agronomy and farm management. A study has also been made of farmers' elevators in Minnesota. A beginning has been made in a study of cooperative creameries and systems of accounting.

At the Grand Rapids substation about 140 acres are devoted to experimental work. Particular attention is given to a study of the cultural requirement on muskeg bogs on which all sorts of cereal, forage, garden, and ornamental crops are being grown. Lime and potash have been found to be the chief limiting factors of growth.

The following publications were received from this station during the year: Bulletins 148, Barley Investigations; 149, Corn, I and II; 150, Tobacco Growing in Minnesota; 151, Quack-grass Eradication, I and II; 152, Farmers' Elevators in Minnesota; 153, Fruit and Vegetable Diseases and Their Control; 154, The Cost of Producing Sugar Beets; and the Annual Report, 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation -----	180,505.94
Farm products-----	63,366.09
Miscellaneous -----	1,433.45
Total-----	275,305.48

The work of the Minnesota station progressed most satisfactorily during the year. There was a fine feeling of enthusiasm and mutual cooperation among the members of the staff, due in part to the careful consideration which has been given to details of organization, with particular reference to the possibility of securing the proper cooperation of different departments and a logical coordination of different lines of work in adjustment with the importance of the problems to be solved.

MISSISSIPPI.

Mississippi Agricultural Experiment Station, *Agricultural College*.

E. R. LLOYD, M. S., *Director*.

The work of the Mississippi station proceeded without essential change of policy or of staff, except for the appointment of H. K.

Gayle, as animal husbandman, to have charge of mule breeding and experiments with beef cattle. The State legislature passed a law requiring that sales funds should be deposited in the State treasury and should not be available for station use. The law, however, was held not to be applicable to the main station where most of the sales funds are derived from Hatch and Adams projects. State appropriations were received in the sum of \$10,500 for the Delta branch station and \$8,500 each for McNeill and Holly Springs branch stations. About 75 acres of land are used for experimental purposes at the main station, the most of this area being devoted to breeding work with corn and cotton, rotation and fertilizer experiments, and for experiments in pig pasturing. The only important buildings erected during the year were a residence and a steer-feeding shed.

Adams fund projects.—In the investigation of mule breeding the station continued its systematic accumulation of available data on types, weights, and measurements of mules produced from mating two types of jack on mares of different weights and measurements. Considerable attention was also devoted to a comparison of the economy in feeding values of different rations for mules and mares of different sizes and ages. In this work it appeared that at prevailing prices the small mule may be produced at a profit of \$28.62 per head, the cotton mule at a profit of \$35.38 per head, and the heavy, work mule at a profit of \$55.48 per head. The total cost of producing 3-year-old mules ranges from \$66 to \$96. A study is also being made of methods of artificial impregnation.

Work on the inheritance of contrasted characters in the cotton plant was continued along the same lines as heretofore. From about 200 F₁ plants seed was obtained for about 6,000 F₂ plants to be used in making further selections. These plants were obtained by crossing two commercial varieties. An attempt is being made to secure pure strains for further hybridization work. Some evidence was obtained of natural crossing between cotton varieties with red and green leaves.

The bacteriological effect of green manures was studied with particular reference to the influence of different quantities of alfalfa as compared with equal amounts of oat straw. The results indicated that the larger the application of alfalfa the larger the yield. No limit was reached for the beneficial effect of alfalfa but the maximum benefit from oat straw was obtained from an application of 4 tons. Bacterial counts agreed closely with the vegetation tests. This work is carried on largely in the greenhouse by means of pot experiments.

The study of forage poisoning was confined largely to an effort to isolate the harmful substances found in the seed heads of *Paspalum dilatatum* as a result of infestation with *Claviceps paspali*. A method was devised for making extracts of the seed heads and an

effort is being put forth to obtain the toxic bodies in a pure state. Feeding experiments with guinea pigs showed that the sclerotia of *C. paspali* are poisonous, 1 gram of the extract producing death within a few hours. The extract obtained from this material is of a greenish color and oily nature.

Work was begun actively on the new project relating to corn breeding. Preliminary results indicated increased yields due to hybridization. Variety tests have been begun to get material for ear-to-row tests to furnish material for a study of correlation.

In the investigation of the biology of crawfish additional data on their life history were secured with reference to species which occur in Mississippi and elsewhere. Additional data were also recorded on the distribution and the host relations of certain species of scale insects. The cottony cushion scale was found for the first time in Mississippi. Further information was obtained regarding pecan insects. Collections were made in the Gulf coast region and some work was done on the distribution, life history, and habits of certain pecan insect pests. Special attention was given to the attacks of beetles belonging to the genus *Lachnostenra*.

Work with Hatch and other funds.—A large amount of work was performed by the different departments of the station under the support of Hatch and other funds. The dairy department completed its experiment in feeding cottonseed meal to cows. A feeding test is in progress in which corn and sorghum silage are compared with Johnson grass hay. Three pounds of silage were found to be equal to 1 pound of hay, sorghum appearing to be equal to corn for silage. An investigation has also been begun of the loss of milk fat in milk separators, the average loss being found to be 3.5 per cent of the milk fat. The department is attempting to determine the cause of this loss. Some work was also done on the manufacture of commercial buttermilk, during which various combinations of bacterial starters and temperatures are being compared. A comparison of ordinary cottonseed hulls and lintless cottonseed hulls for dairy cows gave results in favor of the lintless hulls.

The division of animal husbandry carried on considerable work in feeding beef cattle. These experiments are conducted from the standpoint of breeding and economy in feeding. The basis of the experiment is the native scrub cow mated to Shorthorn, Hereford, and Angus bulls. Experiments are in progress to determine the value of different kinds of silage in feeding mature animals and in feeding for baby beef. Striking success was had in the production of baby beef. The other work of the division included experiments in wintering calves and beef cows, the value of pasture, and feeding experiments with hogs.

The agronomy division is supported wholly by Hatch funds. During the year experiments were conducted on corn, small grains, forage crops, cotton, soil fertility, fertilizers, subsoiling, and rotations. Experiments with slaked and crushed lime in different amounts and in combination with rock phosphate gave increased yields of corn, cotton, oats, and peas from all forms of lime. The experiments in crop rotation included continuous cropping of corn, cotton, and oats, and two, three, and four year rotations in which legumes were involved. Corn has steadily diminished in yield on the continuous-cultivation plats. Where cowpeas have been planted at the last cultivation the yields have been maintained practically without change. On the plats on which a small application of manure was made in addition to the cowpeas the yields have been increased. A rotation with silage corn and crimson clover appears to be quite satisfactory. In continuous culture experiments with cotton this crop seemed not to fall off as rapidly in yield as did corn. A comparison of various forms of potash was begun, particularly on cotton. It is expected that this experiment will continue for several years. A number of miscellaneous experiments were also conducted, including subsoiling for corn, cotton, and oats, the use of dynamite in preparing the land for crops, and variety tests with cotton and forage crops.

The miscellaneous work in bacteriology included studies of various plant diseases and the preparation of material for the pathological collection. The veterinary division devoted some attention to a study of the value of different kinds of pasture for pigs supplemented with grain, peas, beans, and commercial feeds. The entomological division also made a study of *Batrachedra rileyi*, an insect injurious to corn, and of mosquitoes.

The poultry experiments were confined largely to a study of the effects of cottonseed meal in rations. In comparing cottonseed meal and beef scrap for egg production, a slight increase in the total number of eggs and a considerable increase during the molting period were noted in hens fed cottonseed meal. No apparent effect upon the health of the fowls was observed. A study has been begun of the influence of cottonseed meal on the fertility and hatchability of eggs.

At the Delta branch station the principal line of work was cotton breeding. Some experiments were also begun with beef cattle and feeding experiments with hogs will be undertaken later. At the Holly Springs branch station soil conservation is occupying most attention. The soils of this region are badly eroded and experiments on terracing and other methods of prevention are under way. At the McNeill branch station attention is given chiefly to soil renovation, dairying, and fertilizer experiments.

The publications received from this station during the year were as follows: Bulletins 171, Experiments with Small Grains; 172, For-

age Crops; 173, Cotton Experiments, 1915; and Technical Bulletin 6, Forage Poisoning Due to *Claviceps paspali* on Paspalum.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation for substations	21,025.00
Fees	376.00
Farm products	12,983.09
Miscellaneous	106.60
Balance from previous year	1,944.31
 Total	 66,435.00

The Mississippi station is carrying on several different lines of investigation in a satisfactory manner. On the whole, the work of the station is in good condition and its value to the State is increasingly evident.

MISSOURI.

Missouri Agricultural Experiment Station, Columbia.

F. B. MUMFORD, M. S., Director.

The organization and general administration of the Missouri station have resulted in satisfactorily systematizing administrative matters and providing for the strengthening of the staff in several particulars. All the work of the station is on a project basis. The photographic work has been placed in the hands of an official photographer, thus considerably reducing the expense for cameras and photographic supplies. The main agricultural reference library has been placed in the new university library building, completed during the year. The plan of offering fellowships and scholarships to encourage men to take advanced work has been adopted. Many of the men who take advantage of this opportunity are employed on certain of the projects in station work.

The station receives \$30,000 from the State to be used for investigation and also considerable income from fertilizer control, making the total revenues of the station about \$100,000 a year. The department of soils has been authorized to locate several additional soil experiment fields.

Adams fund projects.—The study of the use made of food by steers at different ages and in different conditions involved the analysis of the bodies of calves taken at birth from the experiment on heifers grown under different planes of nutrition. These analyses were made to learn the composition of the calves at birth. Other animals on different planes of nutrition were selected, slaughtered, and analyzed to determine the change of ash at different ages. Some

of the results have been prepared for publication relating particularly to the effect of a limited food supply on the growth of the young beef animal.

Further investigations were made on Mendelian inheritance in domestic animals. The work during the year was concerned largely with the mode of transmission of color pattern of Black and Silver-Spangled Hamburgs and of the method of transmission of the hen-feathered condition in the Seabright bantam. The color pattern in Hamburg fowls was found to be a sex-linked character. Some disturbing factors, however, may interfere with its normal development. The star-spangled condition on a white or golden background can be transferred.

The factors influencing the normal rate of growth in domestic animals were studied by means of digestion trials and analyses of the feed. This project is conducted in close connection with the project on the use of feed.

The project on age as a factor in animal breeding involved the study of the influence of early mating on the mother and on the vigor and thrift of the offspring. Quite conclusive evidence was obtained that early breeding permanently stunts the mother. In studying the effect of pregnancy upon the growth of the mother, it was found in a large number of cases that this condition stimulated rather than retarded growth. Further investigation brought out evidence that stunting from early breeding is due to lactation. Growth is largely inhibited during lactation and starts again after the calves are weaned. With regard to the effect of early mating on the offspring it was found that in the case of immature parents the offspring are not inferior in size, vigor, or other qualities. This work has thus far involved a study of more than 500 animals.

Interesting results were obtained from a study of the influence of nutrition of heifers during their growing period upon their subsequent functional activities. Measurements have been made on several hundred animals. A tentative curve has been established for Jerseys and Holsteins which is used to measure comparative effects of the experimental feeding. For the past two years work has been done on the protein requirement for growth. In this study heifers are kept under observation from the age of six months to the time of calving to determine the effect of rations containing from one-half up to the full feeding standard of protein. A heavy ration resulted in a more rapid growth of skeleton, especially during the active period of development. The heifers which received a heavy ration during growth were slightly inferior in milk production to those which received a light ration. Records compiled from the university dairy herd for 22 years indicate that the highest milk produc-

tion is obtained from cows which have become mature before lactation begins.

In continuing the study of the factors which influence the chemical and physical properties of milk, attention was given chiefly to the effect of cottonseed meal and silage. It was found that other feeds used in connection with cottonseed meal modified the effect of the latter upon milk fat. Silage seems to counteract the hardening effect of cottonseed meal. The effect of silage is apparently due to the lactic acid and continuous feeding with silage increased the volatile fatty acids, while cottonseed meal had the opposite effect.

The study of the physiological relations of powdery mildews to their hosts was continued with particular reference to the nature of physiological species of powdery mildews. A large mass of data has also been accumulated on the effect of plant nutrition on infection, and on stimulation by various salts. Some attention was given to the relation of light and carbon dioxid to infection by powdery mildews.

The study of the development of the various parts of the corn plant has been duplicated for three successive seasons on plants grown in pots. The results indicate that the second growing period is the important one for nutrients and for moisture. The stalks, ears, and roots of the corn plant will be analyzed and the work will be repeated for another season, after which the results will be brought together for publication.

The project on the dormant period of plants was continued actively. The results of respiration studies and other tests indicate that the specific effect on dormant woody tissue of all agents used for breaking the rest period is the stimulation of enzymes. It appears that diastatic, proteolytic, fat-splitting, and oxidizing enzymes are rendered more active by treating twigs with ether and other agents. The tentative conclusion was reached that in woody plants the rest period sets in on account of the inhibition of enzym activity as a result of the overaccumulation of the products of their work. The investigation has involved the use of radishes, tomatoes, and other plants. Marked stimulation was shown from etherizing radishes. With tomatoes increased vegetative growth was induced by keeping the plants under bell jars at night. Reproductive activity was greatly stimulated by etherizing the roots of tomatoes. Some attention has been given also to the effect of the addition of fertilizers in relation to the rest period.

The study of the nutrition of orchard fruits and strawberries was actively continued in relation to disease resistance. Nitrogen has proved advantageous on peaches, but young apple trees showed only a slight advantage from the application of fertilizers even on pine barrens. Some of this investigation is conducted on young trees in

large tubs. When planted in sand alone the growth of such trees was doubled by the addition of nitrogen with or without the addition of phosphoric acid.

In continuing the study of hog cholera with reference to the factors concerned in immunity, attention was given to complement fixation and the study of the ulcers produced in the course of the disease. Reactions have been secured with antigens prepared from spleen extract of diseased hogs. An attempt is being made to devise a method for differential diagnosis of hog cholera without killing the hog. Experiments are also under way to learn how long the virus of hog cholera will live under various conditions.

Work with Hatch and other funds.—The chemical department cooperates with the department of soils, farm crops, and dairying and does the analytical work in connection with soil surveys and fertilizer inspection. A chemical study was made of the timothy plant. It appears that timothy takes up nitrogen and ash constituents most rapidly during the young stages of growth. In the older stages of growth nitrogen-free extract increases at the highest rate. As the timothy heads approach full ripeness a noticeable increase of phosphorus occurs.

The horticultural department conducted experiments on orchard tillage, bud selection in strawberries and apples, cultural experiments with apples and cherries, and the development of buds on apple trees. A comparison of sod mulch and clean culture in orchards indicated that sod mulch diminished the growth of trees. Blue grass caused the greatest diminution, with alfalfa following. A study of the sap from trees growing in the alfalfa plats indicated a high concentration and a low freezing point. Apparently legumes exercise an influence toward hardness of apple trees. No increase in yield has been brought about by bud selection in strawberries. In comparing fall planting with spring planting of cherries a much smaller loss occurred in the fall-planted trees. A study is also being made of fruit-bud development of apple trees as influenced by the previous crop of fruit. A majority of the spurs which bore the previous year did not bear again the following year. It appears impossible for the same spur to produce fruit and store up sufficient material for the following year.

The dairy department continued its investigation of the yellow coloring matter of egg xanthophyll. It appears that the hen uses carotin but not xanthophyll as a coloring matter of fat. Silage investigations were continued with particular reference to temperature conditions. The normal temperature of silage when put in the silo was found to range from 75° to 95° F. The temperature rises from 3° to 15°, reaching a maximum in from 8 to 12 days, after which the temperature slowly declines. The highest temperature

of silage rarely exceeds 100° F. The most important factor in the variation of the temperature of the silage is the amount of air contained in the silage.

The poultry experiments included a comparison of sour milk and beef scrap for egg production. In feeding for egg production grain, animal food, grit, green food, clean water, exercise, liberal rations, and regular attention are considered necessary to success. The regular daily ration for 100 hens is from 19 to 25 pounds of good mixed rations.

The veterinary department made a study of contagious abortion in cooperation with the dairy department. An attempt is being made to devise a rapid method of diagnosis. Control experiments were conducted by the use of modern sanitation, methylene blue, and carbolic acid. An attempt is being made to determine how long the infected animals will carry the pathogenic organism. Further work on von Behring's method of immunization against tuberculosis gave negative results. Some attention was given to sterility in swine and vaccination of poultry for roup.

The department of animal husbandry made experiments in feeding silage to beef animals in connection with different amounts of concentrates. The animals which received a large amount of silage gave as good returns as those which received more corn. It was also found that silage could be substituted for about one-half of the hay in rations for work horses. In a study of forage crops for pigs the best results were obtained with rape. Hogging down corn with soy beans gave better returns than corn alone. An experiment was undertaken to determine the value of wheat for hogs. Hogs fed wheat made more rapid gains than those which received corn. During a feeding period of 120 days the hogs which were fed wheat made an average daily gain of 1.25 pounds, while the hogs on corn gained 1 pound per day.

The soils department summarized the results obtained on rotation experiments which have been in progress for 25 years. The material is being prepared for publication. Soil management experiments are under way on 12 experimental farms. A soil survey is being conducted in cooperation with this department. This work covers about four counties each year. The survey is now complete for 42 counties. An experiment has been started to study the accumulation of nitrogen and organic matter in soils. On one series of plats clover will be grown and turned under each year, on another series clover will be taken off, and in still others cowpeas followed by rye will be turned under. In one instance on uncropped land an erosion of 0.41 inch occurred during a single season, representing a loss of 200 pounds of nitrogen. Attention is also being given to the capillary movement

of soils and to the question whether corn grown in conjunction with cowpeas derives nitrogen from the latter.

The work of the entomological department was concerned chiefly with a study of the periodical cicada, Hessian fly, cucumber beetle, melon aphis, scale insects, nursery inspection, and beekeeping. The efforts of the botanical department were largely devoted to a study of rusts, particularly the relative resistance of different varieties of oats and to a study of the smuts of wheat, oats, and sorghum. Some attention was also given to the diseases of timber trees, fungi in silage, and Fusarium disease of watermelons and cowpeas.

The department of farm crops carried on cultural and variety tests of staple crops. A prominent feature of this work was wheat breeding. Some promising pure lines of wheat, showing quite large increases in yield, have been developed. The influence of environment on the wheat plant is being studied in cooperation with Cornell University. Some attention has been given to the inheritance of quantitative characters in wheat. Quite extensive variety tests of corn, wheat, oats, barley, cowpeas, and soy beans are under way as well as experiments to determine the influence of depth of planting and time of seeding standard farm crops.

The following publications were received from this station during the year: Bulletin 133, The Silo and Its Use; 134, Insect Pests of Field Crops; 135, The Ration and Age of Calving as Factors Influencing the Growth and Dairy Qualities of Cows; 136, Feeding Wheat to Fattening Swine; 137, The Periodical Cicada in Missouri; 138, Farm Beekeeping; 139, Inspection of Commercial Fertilizers, 1915; 141, Work and Progress of the Agricultural Experiment Station for the Year Ended June 30, 1915; Research Bulletins 17, An Experimental Study of the Rest Period in Plants—Seeds; 18, The Maintenance Requirement of Cattle as Influenced by Condition, Plane of Nutrition, Age, Season, Time on Maintenance, Type, and Size of Animal; 20, Studies of the Timothy Plant, II; 21, An Experimental Study of the Rest Period in Plants, V; 22, Silage Investigations—Normal Temperatures and Some Factors Influencing the Quality of Silage; Circulars 75, The Farmer's Poultry House; 76, Feeding for Egg Production; 77, The Value of Education to the Farmer; and 78, The Control of Soil Washing.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation-----	17,281.77
Fees, including balance from previous year-----	30,136.03
Farm products, including balance from previous year-----	31,788.09
Miscellaneous-----	14,748.23
Total-----	123,954.12

The Missouri station is in excellent condition from the standpoint of its administration and its investigation. Effective use is being made of the funds intrusted to it.

MONTANA.

Montana Agricultural Experiment Station, Bozeman.

F. B. LINFIELD, B. S. A., *Director.*

A reorganization of the educational institutions of the State was made during the year. E. C. Elliott was appointed chancellor of the University of Montana, comprising the State university, the agricultural college and experiment station, the school of mines, and the State normal school. From the standpoint of the experiment station the new organization of the State institutions is working satisfactorily. Cordial relations have continued with the farmers of the State and all farmers' organizations have shown active sympathy with the station. Moreover, the relations between the members of the staff have been extremely harmonious.

No station men are doing extension work. They occasionally go into the field for a week or less, but these short trips are so planned as not to interfere with research. Teaching and station work are separated as sharply as practical, the assistants are exclusively teachers or station men, and there is no splitting of the time of the men except in the case of the heads of departments. About 100 acres at the main station are used for experimental purposes. The Fort Ellis substation, used almost entirely for experiments, has an area of 600 acres, the Havre substation 200 acres, the Moccasin substation 600 acres, and the Corvallis fruit substation 20 acres. No important changes in station policy or staff were made during the year.

Adams fund projects.—The study of the sugar-beet louse and cut-worms made decided progress. Beneficial effects from irrigation in destroying sugar-beet louse were obtained and further experiments along this line are planned. Evidence was secured that there are two species of sugar-beet louse. A dipterous parasite has been discovered belonging to the genus Chlorops. This parasite appears to be extremely effective. In studying the egg-laying habits of cut-worms the interesting fact was determined that while the moth appears in July it does not lay eggs until September.

The various stages of development of the western wheat aphid were carefully studied in the field and insectary. This pest is becoming more abundant in the State, particularly in the Judith Basin. Attention is now being given to parasites of the pest and methods of control. Apparently clean summer fallow is an effective means of controlling the insect.

In further work on the physiological effects of arsenical compounds, the study of the injury to apple trees by arsenic absorbed through the bark was completed and much progress was made in investigating the injury to foliage. Arsenical sprays were found to cause injury to the crown of apple trees somewhat in the manner shown by the Colorado station. It appears that the chief factor favoring arsenical injury to leaves is humidity of the air. Soap increases the solubility and therefore the injurious effects of all arsenicals except Paris green. This is explained as meaning that soap throws copper out of the solution, thus increasing the solubility of the arsenical sprays.

The brown bark spot of fruit trees received much attention. It appears doubtful whether the disease is parasitic. At least, no organism has been found except such as must be considered merely saprophytic. Negative results were also obtained from numerous inoculations and from spraying experiments. It was found that if a graft be set in a badly diseased tree it will make a healthy growth.

The project on canker and other orchard tree diseases was continued actively. In cases of canker the pathogenic organism was found and was determined as *Cytospora leucostoma*. The fungus appears not to attack healthy trees but gains entrance to trees after they have suffered from winter injury, sun scald, or wounds. It was quite definitely determined that black heart is not a specific disease, but merely a form of winter injury. Collar rot was shown to be parasitic, but the pathogenic organism has not yet been isolated.

In the study of factors affecting wool it was found that temperature and humidity at the time of testing influenced the results considerably. Much effort was spent, therefore, in studying this matter. It appears necessary to determine and state the humidity of the air at the time of the test in reporting on wool strength: Otherwise the testing records can not be correlated with those obtained by other investigators under other conditions. The diameter of the wool fiber is increased with a rising humidity but the strength is diminished in proportion to the size of the diameter.

The project on the correlation and inheritance of characters in pure lines and varieties was confined during the year to work with Sixty-Day oats. The plant-to-row system was adopted at the beginning, and by this method 41 rows of oats were secured. The first two years' work have shown that apparently no further characters can be fixed by pure-line selection by starting with a pure line.

Work on the projects concerning the relation of water loss to dry weight of plants, the conditions which favor the formation of nitrates in the soil, and methods for utilizing light rainfall of the semiarid districts was closely correlated. The relation of water loss to the

dry weight of plants was studied largely on barley, oats, and wheat in square-cornered cans having dimensions of 16 by 43 by 36 inches. The wilting point of the soil in the cans was determined to be 10 per cent of moisture. The soil in the cans is maintained at 18 per cent of moisture. It appears that check tanks lose 6 to 10 pounds of water during the whole season, while cropped tanks lose about 300 pounds. The plats used in this experiment are maintained under different systems of cropping, some being cropped continuously while others are in rotation. Manure and summer fallow are also concerned in this investigation. In the continuously cropped plats it was found that the water is removed to a depth of $4\frac{1}{2}$ feet. At Fort Ellis the wilting point in the surface soil was determined as 7 to 8 per cent, at 6 feet as 10 per cent, and at 10 feet as 20 per cent. Little movement of water occurs from below 5 feet upward. In some of the continuously cropped plats the percentage of nitrogen is higher than at the beginning of the experiment, the conditions in this regard being similar to those observed at the Colorado station. About 3,000 determinations of nitrates and nitrites were made during the year. It was found that the addition of an alkali salt to the soil causes a great increase in the amount of nitrates, in some cases producing a rise of nitrates from 240 to 3,750 parts per million. In some of the pots a gain of 4 per cent in total nitrogen took place within three months. Certain soil spots were found containing 8 per cent of nitrate nitrogen. Some of the soils of Montana appear to contain in their natural condition Ashby's artificial formula for nitrogen fixation.

In continuing the study of the incubation of hens' eggs, the lime and phosphoric acid in the eggs at different periods of incubation were determined, the eggs being analyzed in the fresh condition, on the tenth and on the fifteenth day of incubation. Analyses were also made of the chick. A relation was found between the lime-phosphoric acid ratio and the vitality of the chick. The best ratio is apparently that which is found in tricalcium phosphate.

Work with Hatch and other funds.—The department of agronomy carried on a large amount of work during the year. These experiments included variety tests with cereals, fertilizer tests with beets, experiments with different rates and dates of seeding flax and peas, cultural experiments with forage crops, irrigation tests, experiments on the effect of straw mulch on soil moisture and temperature, tests to determine the moisture-conserving effect of surface tillage, rotation experiments, and dry farming with particular reference to grain and forage crops. It was found that a straw mulch lowered the soil temperature 5° to 10° F. and correspondingly increased the moisture content. In the case of turnips the yield was much higher without

mulch. In fertilizer experiments with cereals acid phosphate applied at the rates of 300, 500, and 700 pounds per acre showed no effect upon the yield—in fact, the heavy applications of phosphoric acid lowered the yield.

The department of agricultural engineering conducted experiments in pumping, particularly with electrical energy; treatment of fence posts, sewage disposal, drainage, and tests of the draft of farm implements. It was found that the fuel consumption required to raise 1 acre-foot of water to a height of 1 foot is about one-half gallon of gasoline. Distillates and kerosene proved to be cheaper for power purposes than gasoline. Extensive seepage experiments in the Gallatin Valley are in progress. In constructing surface ditches dynamite proved to be cheaper than hand work. A tractor test for farm work is being conducted to throw light on the relative economy of tractors and horse labor.

The department of animal industry conducted experiments in beef production, the use of sunflowers for silage, feeding pigs and dairy cows, and methods of reseeding dry-land pastures, the last experiment being in cooperation with the department of agronomy. A study is also being made of maintenance rations for breeding ewes in which local feeds, barley, clover, alfalfa hay, and Montana grains are employed. A reasonable profit from winter feeding beef animals was shown even on high-priced grains if the steers are sold at an age of 13 months. The cost of keeping a beef cow for one year was found to be from \$10 to \$12. No profit was shown from feeding 18-months-old steers on local feeds for a period of three months.

The entomological work of the station included the study of the house fly, the spotted-fever tick, wheat-sheath miner, and general entomological observations. Some interesting results were obtained in a study of the dispersion of the house fly under city conditions. The experiment involved the release, after marking, of 400,000 flies. Some of the flies were captured at a distance of 3,500 yards from the point where they were released.

The chemical department is making a study of the infertile soils of Montana. Some of these soils show an excess of alkali, while others are deficient in nitrogen or lime. In a few localities soils are infertile on account of an excess of nitrates. The department cooperates actively with the departments of agronomy, animal industry, and horticulture. Considerable work was done on the digestibility of silage. Sunflower silage was found to be fully equal to clover silage in feeding value, and a yield of about 30 tons of silage per acre was obtained from the sunflowers.

The department of farm management, in cooperation with this department, is carrying on surveys, particularly a sugar-beet survey near Billings, Mont. Some work was also done on a farm survey

of the Gallatin Valley. In this work it appears that in order to secure the maximum service from land, labor, and equipment farms should range in size from 200 to 400 acres. It was also found that farmers who sold a large part of their crops obtained the largest labor income. Farmers who derived one-third of their receipts from domestic animals made a larger labor income than those who derived either more or less from farm animals. Moreover, it was found that on dry land the most profitable farms have the least live stock.

The veterinary department carried on experiments in the treatment of contagious abortion, hairlessness of pigs, and bovine tuberculosis. It has been found that tuberculosis is widely distributed in poultry, sparrows, and other birds throughout the State, while bovine tuberculosis is comparatively rare. In feeding experiments with calves milk treated with formalin at the rate of 1 part to 8,000 was used. The formalin preserved the milk in a sweet condition for four days, and milk thus treated gave as satisfactory results as fresh, untreated milk. In experiments with contagious abortion good results have been obtained in preventing the development of the disease by feeding a 4 per cent solution of carbolic acid in doses of 200 to 400 cubic centimeters in the ration. Interesting results were obtained in a study of the hairlessness of pigs and other animals. The disease occurs extensively in the Yellowstone Valley. Goiter develops in connection with hairlessness of young pigs, calves, lambs, and colts. The trouble was entirely prevented in one instance by feeding sows potassium iodid. This experiment will be repeated. The trouble appears to be one of nutrition and not of infection.

The poultry department conducted experiments in breeding for egg production, feeding experiments with animal food as a means of forcing egg production, fattening roasters in crates, and a study of the cost of producing mature pullets. It was found that while White Leghorn hens 2 or 3 years old may produce a large number of eggs, sometimes in excess of the first-year production, yet the egg production in winter is lower than during the pullet year. In experiments on the value of animal food as a means of forcing egg production the indications at present are that skim milk in addition to other feed will produce more eggs than green-cut bone, commercial meat scrap, or fish scrap. A test of the crate fattening of roasters indicated that the farmer will find it profitable to use some such means of fattening his fowls before marketing them.

The work of the horticultural department involved a number of lines of investigation, such as orchard cultivation, thinning potatoes, pure-line selection of potatoes, a study of premature seeding of celery, thinning of apples, and miscellaneous work with ornamentals. In the Bitter Root Valley it was found that clean cultivation of orchards is not a good practice. Good results were obtained from

planting potatoes at a distance of 15 to 16 inches in the row. The cost of thinning potatoes to one stem in the hill was \$2.50 per acre. This practice reduced the total yield, but greatly improved the quality of the potatoes and largely eliminated the culls. The practice was found also to improve the shape of the potatoes. By means of pure-line selection it was found that yield is not hereditary in potatoes. The application of a mulch in potato culture showed an unfavorable effect upon the yield. The premature seedling of celery was found to be due to early planting, growing seedlings in rich soil in the greenhouse, and heavy pruning. In experiments in thinning apples an attempt was made to study the relation between the form of the apple and the length of the stem. The apple from the central blossom of the flower cluster was found to be of the best form in the case of Black Twig variety and of the poorest form in the case of Red Mackintosh.

The following publications were received from this station during the year: Bulletins 104, Tomato Tests; 105, The Intradermal Test in Bovine Tuberculosis; 106, Thinning Experiments with Potatoes; 107, Corn in Montana—History, Characteristics, Adaptation; Circulars 44, Tomato Culture in Montana; 45, Crop-growing Suggestions to Dry-land Farmers; 46, The Potato Crop in Montana; 47, Control of the Army Cutworm; 48, Flax Crop Conditions for 1915; 49, Suggestions to Alfalfa Growers; 50, Growing and Fattening Hogs in Montana; and the Annual Report for 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	55,947.18
Farm products	5,575.03
<hr/>	
Total	91,522.21

The general condition of the Montana station is excellent. The organization has been well worked out with reference to a clear and satisfactory relation between station, teaching, and extension work. Nearly all of the Adams fund projects involve the cooperation of different departments in a manner mutually satisfactory. Moreover, the farmers, as shown by official action of their various organizations, thoroughly appreciate the work of the station.

NEBRASKA.

Agricultural Experiment Station of Nebraska, Lincoln.

E. A. BURNETT, B. S., *Director.*

The year was very successful and prosperous for the Nebraska station. The new dairy building (Pl IV, fig. 1) was nearly completed

at a cost of about \$178,000. Modern equipment is being provided which will bring the total cost of the building to about \$193,000. The university pursues a very liberal and helpful attitude toward the station, and the allotments from the general university funds to the departments of the agricultural college are available in part for the experiment station. It is estimated that from \$15,000 to \$20,000 are annually devoted from this source to experimental work. The station also has for its use a special printing fund of \$2,500. The area used for experimental purposes amounts to about 250 acres, of which the agronomy department has 135 acres. W. W. Burr was elected professor of agronomy and agronomist at the experiment station and W. J. Morrill was appointed as forester.

Adams fund projects.—The project on the water requirements of crops was actively continued, the influence of acclimatization, variety, and kind of crop upon transpiration being studied in 400 potometers. Corn acclimatized to the climate of New York did not differ materially in its water requirements from corn acclimatized to the drier soil of western Nebraska. Varieties of corn showing difference in size indicated some variation in water requirement. Chinese and Esperanza corn, which have been described as especially drought resistant, show practically the same water requirement per pound of dry matter as the average for 11 of the other varieties under experiment. Milo maize also showed practically the same water requirement as corn. Sunflowers, on the other hand, used more than three times as much water per plant as corn, while the water requirement per unit of dry matter was double that of corn. The small early varieties of corn appear to have the lowest water requirement. Incidentally it was found that the error of observation in small cans is due largely to starvation of the corn. The same amount of soil placed in large cans and mixed with sand gives the same results as in small cans.

In studying the effect of thickness of stand on cereal plants, attention was given chiefly to wheat and oats planted in rows and in five-row blocks, thick and thin rows alternating. In this experiment large and small seed are also under comparison. It has been found that the results are vitiated if different varieties are planted in juxtaposition, since some varieties naturally grow more vigorously than others, and thus overtop the smaller varieties and confuse the results. Evidence was obtained that when small seed are planted in equal numbers with larger seed the yield is less than the smaller seed, but when planted in equal weights the yield is about equal.

The study of the effect of close breeding in maize was started by the method of ear-to-row breeding. From these preliminary experiments four strains were obtained which had been inbred for seven years. The work involves a comparison of inbreeding in which the

pollen of the corn plant is applied to the silk of the same plant with close breeding, in which a composite sample of pollen is sprinkled on the silks of one row, thus keeping within the confines of a narrow family. It has been found that inbreeding greatly reduces the vigor of the plant within three generations, while close breeding, on the other hand, leaves the offspring almost normal.

The investigation of potato diseases was concerned largely with species of *Fusarium* as related to dry rot. Two species of *Fusarium* have been separated on a strictly physiological basis. One of these species is active in the field and the other in stored potatoes. The species which is active at low temperatures causes rot only in storage, while the species which thrives best at high temperatures is typically a wilt-producing species. Both species may cause wilt of the foliage or under other conditions may cause rot. Some attention was also given to leaf roll or curl of potatoes.

The project on apple blister canker is largely a study of the life history and pathogenicity of *Nummularia discreta*. The course of the growth of the hyphae in the wood is being carefully studied. The disease is widely distributed in the State, affecting chiefly the apple, but also the elm and mountain ash. No fungicides have shown any effect upon it, but the trouble may be eradicated by careful excision of these parts and by treatment of the wounds. Considerable work was also done on certain little-known plant diseases, particularly timothy rust, *Rhizoctonia* in relation to potato scab, and corn smut. In connection with the study of potato scab careful anatomical studies were made, involving also the sweet potato.

Some interesting findings were made in the study of corn pigments. When a purple pigment is crossed on a green pigment it was found to give a brown pigment, the latter appearing to be an oxidation product of the purple pigment. Some evidence had been obtained that the basal purple color is a glucosid which becomes brown by oxidation. Both the purple and brown pigments are water soluble. Thus far the pigments have been obtained in amorphous condition, but it is hoped to secure them in a pure crystalline form.

The chemical study of silage made considerable progress. Attention was given largely to a study of the composition of gas in silage and the production of oxids of nitrogen which take place in the corn silage within the first 15 hours after filling the silo. The relation of lactic acid to volatile acids is also under investigation. The work is being carried on chiefly with alfalfa and various mixtures. It has been found that pure alfalfa silage sometimes develops a putrefaction. Distinct progress was also made on the project on the organic constituents of soils. Much effort is being devoted to the

study of vanillin and other organic compounds which appear to act quite differently toward wheat plants in soils and water cultures. This difference is believed to be due to adsorption and oxidation.

In continuing the study of pollination in alfalfa some trouble was experienced from the destruction of alfalfa plants by a hail storm. The insect visitors of alfalfa have been carefully studied for five years and a large mass of data has been accumulated, showing the species which are actually concerned in fertilization. The complete tabulation of the results will be possible after growing one more crop of alfalfa in the experimental cages.

In the investigation of food requirements of dairy cows 16 cows, 8 Jerseys and 8 Holsteins, were used. Four rations were employed, four cows being maintained on each ration. At six-months intervals a 10-days' digestion trial is carried out. An attempt is being made to formulate for dairy heifers a feeding standard for the growing period and to determine the normal growth of heifers.

The study of winter injury to trees was confined largely to the determination of critical temperatures at which apple stocks are injured. It was found that most of them were killed or injured by temperatures ranging from -10° to -15° C. Seedling apple stocks show a great variation in resistance to cold. In some cases the stock roots are killed while the scion roots are uninjured. Soil temperatures are determined by means of electrical-resistance thermometers placed at depths of $7\frac{1}{2}$ and $9\frac{1}{2}$ inches in each plat and read twice daily. An attempt will be made to correlate soil moisture and temperature conditions with the relative degree of freezing in the apple stocks.

Work with Hatch and other funds.—The work of the animal-husbandry department included a number of feeding experiments. A comparison was made between various practical rations in feeding cattle, particular attention being given to the value of silage and alfalfa hay. Alfalfa was also compared with cottonseed meal. In comparison with alfalfa, silage appeared not to be an economical feed for beef. An experiment in the use of self-feeders was tried with hogs of all classes and ages and with various classes of feed. It appears that for fattening hogs the self-feeder is the most economical method, but this is not the case with breeding sows. A feeding experiment with 325 lambs allowed to run on pasture was conducted during the year. An attempt is being made also to determine the effect of clipping lambs in the fall upon subsequent growth. The addition of corn silage to a ration of shelled corn and alfalfa hay increased the daily gain in lambs and also the cost of production, but did not affect the net profit.

In experimental agronomy a large variety of work was accomplished, including a test of closeness of planting corn, rotation experiments, and variety tests with grain. It was found that the closer the competition in corn the greater the advantage of the more vigorously growing variety. A four-year rotation was in progress on 20 acres of the station farm. Variety tests with small grains and breeding work with wheat and oats were also carried on. Some attention was given to pasture mixtures and to the effect of depths and time of plowing for fall wheat.

Nursery and orchard inspection takes up much time of the entomological staff, but experiments are in progress on means of controlling prairie dogs, pocket gophers, and other rodents, and also on the life histories and means of controlling grasshoppers, Hessian flies, and other insect pests.

The division of agricultural chemistry has reduced the making of miscellaneous analyses to a minimum, thus largely escaping the burden of routine work. A study was made of the colloidal swelling of wheat gluten, during which it was shown that gluten is an emulsoid colloid with all the properties of this class of compounds. Gluten absorbs water from dilute acid solutions, thereby losing its tenacity and becoming soft and gelatinous.

The horticultural work of the station involved the investigation of F_1 hybrids as compared with pure strains of tomatoes, a study of the principles of orchard culture, and spraying experiments. In crosses of 26 strains of tomatoes it was found that most hybrids start sooner and grow more vigorously than pure strains. The principles of orchard culture have been under investigation since 1901. Certain trees from each plat will ultimately be removed to note the depth of the root system in clean culture, sod, and cover crops. Spraying experiments were carried on with pears, apples, and bush fruits. Some work is also in progress in breeding apples and strawberries.

The dairy division studied the use of different crops for silage and carried on feeding experiments for dairy cows and tests of cooling tanks for cream. Silage was prepared from alfalfa and shelled corn, beet tops alone, and sorghum alone. A comparison of rations containing silage with nonsilage rations showed no influence of silage on the milk flow. Moreover, silage appeared not to be a cheap feed as compared with alfalfa. A test of the practicability of feeding cows on roughage alone indicated the possibility of obtaining a relatively high profit from a ration without grain. Comparative tests of various materials for cooling tanks for cream, including ground cork, cork sheets, wood, metal lining, and felt, indicated that the wood tank is perhaps best for farmers.

The following publications were received from this station during the year: Bulletins 152, Management of Irrigated Land; 153, Lamb

Feeding Experiments, I, II, and III; 154, The Prairie Dog and Its Control; 155 (with popular edition), Rotations and Tillage Methods in Western Nebraska; Research Bulletin 7, A Genetic Study of Plant Height in *Phaseolus vulgaris*; and the Annual Report for 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation for substations	29,181.80
Miscellaneous, including balance from previous year	46,414.34
Total	105,596.14

The building fund for the university as a whole is large, and it is expected that the new buildings now in contemplation will give satisfactory accommodation for the natural expansion of the college and station. The station as a whole is in excellent condition, both with regard to the mutual relations of the members of the staff and with regard to the quality of research.

NEVADA.

Nevada Agricultural Experiment Station, Reno.

S. B. DOTEN, M. A., Director.

A new department of range management was established at the station during the year, with C. E. Fleming in charge. On account of the importance of the grazing industry in the State it is proposed to meet the problems of stockmen by a study of various phases of range management, including different methods for handling stock, studies of range flora, and related matters. Corrals and box stalls for horses and a hog house and anthrax stable were built in order to add greater facilities for veterinary investigation (Pl. IV, fig. 2). The station is maintained almost exclusively on Federal funds, receiving only about \$2,000 from the State. All of the work of the station is on the project basis.

Adams fund projects.—Research work in meteorology was narrowed down to an investigation of the influence of mountains and forests upon the conservation of snow. The study of frost forecasting from a station on Mount Rose was abandoned after it was found that it is no more feasible to forecast frost from Mount Rose than from the valley below. It appeared, however, that forecasting from high stations is of some value when taken in connection with the prevailing meteorological conditions. Of the cold waves which occurred on the summit of Mount Rose during a period of four years, about one-half were accompanied by nearly simultaneous changes at the base, while one-third were followed by similar changes within 48 hours. In connection with this work a meteorograph was



FIG. 1.—NEW DAIRY HUSBANDRY BUILDING, NEBRASKA STATION.

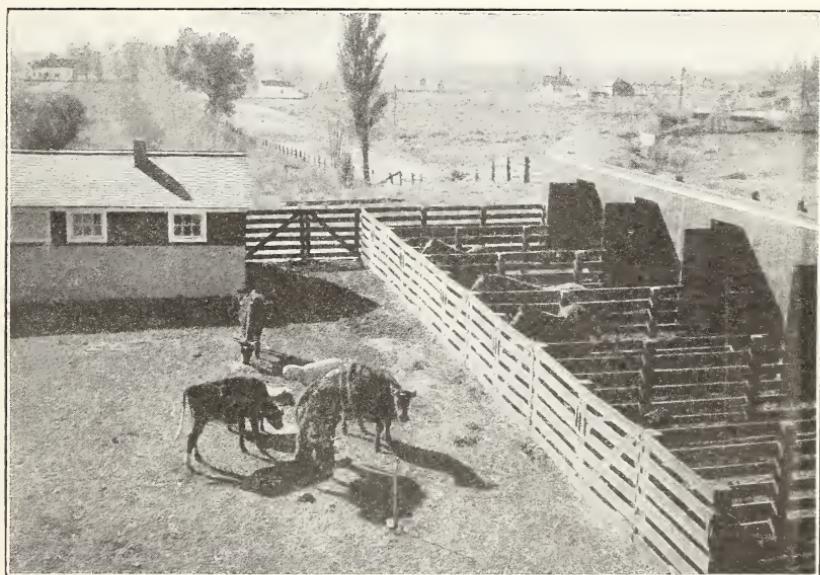


FIG. 2.—SERUM HOUSE AND YARDS, NEW FIELD LABORATORY, NEVADA STATION.



devised consisting essentially of a large cylinder for taking records of all sorts of observations. A table of snow densities has been prepared based on 3,000 measurements. During the past three years snow measurements have been taken at stations 50 feet apart. A study of snowfall from wide areas shows a quite remarkable uniformity. In cooperation with the Weather Bureau, a plan for estimating the amount of water which will be available from the snowfall has been put in operation. The results obtained by the meteorological researches of the station will be put to practical use by the Weather Bureau. Predictions as to the actual amount of available water based on snowfall and density measurements have come remarkably close to the actual water supply.

The project on equine anemia made little progress during the year, largely on account of the fact that the disease practically disappeared in Elko County. The disease appeared in the western part of the State, where it was at first mistaken for anthrax. The reliability of previous results obtained in transmitting the disease by inoculation seems to be questionable and further experiments along this line will be made. In one case organized bodies were found in the blood corpuscles corresponding to those previously noted and described in the course of this work. Attempts at inoculation with defibrinated blood gave negative results.

In continuing the study of hemorrhagic disease among cattle, numerous inoculations were made in rabbits and pure cultures were obtained. The organism was also found in material sent to the station by a practising veterinarian. In an outbreak of the disease in a large herd of cattle over 750 head were vaccinated. Only one of these animals died and the disease appeared to be completely checked. The hemorrhagic disease is distinct from anthrax, although complications with anthrax sometimes occur. The etiology and true nature of the disease are still in doubt.

Considerable success was had in continuing the study of methods for the production of hog-cholera serum free from microorganisms. A method was devised for the separation of globulins by fractional distillation and for concentration of the material. It is believed that if this can be put into practical operation the size of the serum dose may be reduced. The method is being tested in pigs in comparison with ordinary hog-cholera serum. The concentrated material is made from ordinary hog-cholera serum, but the method employed eliminates all bacterial and inert material. Complications due to secondary infection appear to have been eliminated. Incidentally in connection with this project, some attention was given to chicken cholera with particular reference to the production of immunity by the use of dead cholera bacteria. In this study about 725 chickens were vaccinated, with apparently satisfactory results.

A study of contagious epithelioma of chickens was carried forward actively. The vaccine has been prepared and used on a large scale. In the first set of experiments about 2,600 chickens were vaccinated and in all about 58,000 fowls have been treated by this method, with a mortality of 8.24 per cent. The secondary infection has given some trouble. In vaccinating for this disease the use of a virus prepared by triturating the diseased material collected from the skin and mucous surfaces and attenuated for one hour at a temperature of 55° C. promptly checked the spread of the disease and exercised a favorable influence upon already infected fowls.

The investigation of saponin in connection with the project on the relation of nitrogen to the organic constituents of alfalfa was practically completed. By means of dialysis a purified saponin was isolated. The percentage of saponin was determined at one stage of the growth of the plant only. In alfalfa taken just before blooming, saponin constitutes from 4 to 5 per cent of the dry matter. The possible relationship of saponin to bloat has not been investigated. An oil was obtained from alfalfa seed, showing drying properties. Little progress was made in the determination of the exact mechanism by which atmospheric nitrogen is taken into the tissue of the plant.

In continuation of the study of poisonous plants, attention was given chiefly to problems connected with the distribution of alkaloids in *Zygadenus*. For this purpose the leaves, flowers, stems, and tubers of the plants were analyzed to learn whether the same alkaloids were present in all parts of the plant. A noncrystallizable alkaloid reported by the Wyoming station as occurring in this plant will receive further study. A beginning was also made in a study of stock poisoning due to lupines and goldenrod. The departments of veterinary science and bacteriology cooperated in investigating the symptoms of lupine poisoning. A species of goldenrod has been shown to be highly poisonous to sheep, and clinical studies have been made on the poisonous effects of this plant.

Work with Hatch and other funds.—The agronomy department carried on variety tests with cereals, peas, and various forage plants, together with experiments in the production of alfalfa seed and in the use of sweet clover in regions where alfalfa is not well adapted. Experiments on the duty of water were continued with wheat, alfalfa, and potatoes on 61 plats. An attempt is being made to determine whether seeding blue grass with alfalfa will result in a better hay for dairy cows than alfalfa alone. Variety tests with sugar beets, millets, and sorghums were also continued. Several varieties of corn are being grown for the purpose of testing their value in the production of silage. The work of the agronomy department as a whole is grouped under two main projects—crop improvement chiefly with cereals and forage crops and irrigation experiments with wheat, alfalfa, and potatoes.

Irrigation experiments during the year indicated that the yield of alfalfa hay is seriously diminished if the crop is allowed to become slightly wilted before water is applied and that excessively heavy irrigations repeated frequently will produce low yields per acre-foot of water. Under such treatments the hay is coarse and inferior. When potatoes were allowed to become too dry before irrigation a second growth and a lower starch content resulted. Too heavy irrigation, on the other hand, appeared to favor the development of scab. With the wheat crop it was found to be highly injurious to omit irrigation at the time when the head was forming and when the grain was in the milk.

The study of grazing problems was begun in a serious way by the organization of a department for range investigations. It is proposed to study the revegetation of depleted ranges by seeding with natural grasses and also by introducing other well-known native grasses from the Southwest. A study will also be made of redistribution and development of watering troughs for stock. The carrying capacity of different types of grazing land in the State will be carefully observed. Some attention will also be given to poisonous plants and their control.

Some attention was given to the preparation of an anthrax serum and to experiments for testing the efficacy of this serum. Two horses and two burros have for some time been receiving virulent anthrax serum for the purpose of inducing in them the production of a serum which will have protective and curative power.

In connection with the Adams project on nitrogen fixation by alfalfa, analyses were made of the first and second crops of alfalfa for the purpose of determining whether the first crop is superior in feeding value to the second. Ordinarily the first crop of alfalfa matures slowly through the cool weather of spring and early summer, while the second crop matures more rapidly in the heat of mid-summer. Possibly a difference in the chemical composition of the crops may develop under these unlike conditions of growth.

The following publications were received from this station during the year: Bulletins 81, Water Hemlock (*Cicuta*) ; 82, The Control of Contagious Epithelioma in Chickens by Vaccination; and the Annual Report for 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation, including balance from previous year -----	2,000.00
Farm products, including balance from previous year-----	556.51
 Total -----	 32,556.51

A serious consideration of the relative importance of various agricultural industries in the State led to a change of plans and organization, according to which prime emphasis is to be placed upon problems connected with the live-stock industry. This redirection of the station's work is clearly seen in the establishment of the new department for range management. The general outlook for the station has been thereby favorably affected.

NEW HAMPSHIRE.

New Hampshire College Agricultural Experiment Station, Durham.

J. C. KENDALL, B. S., *Director.*

In the spring of 1916 the college purchased a farm containing about 35 acres of tillable land, including an apple orchard. The farm was acquired chiefly for experimental work in horticulture and will be made headquarters for the horticultural work of both the college and station. The poultry plant has also been moved to the new farm. K. W. Woodward succeeded J. S. Foster as forester. C. H. Otis was appointed assistant botanist. Toward the close of the year F. W. Taylor was made dean of agriculture. This arrangement will relieve the director to some extent and enable him to devote his time more completely to the station.

Adams fund projects.—The project on control of root maggots was carried on actively. Various insecticides, particularly tobacco dust, were placed around the base of cabbage and radish plants to prevent the entrance of the maggots. The cost of the application was considerably reduced by mixing lime in equal proportions with the tobacco dust. Certain casein preparations and ordinary paste applied around the plant were also quite effective in preventing insect attacks. Carbon bisulphid was tested without quite satisfactory results, and, furthermore, it was found to be too expensive.

The causes and means of control of fruit-bud formation on apple trees were studied with satisfactory results. Daily records were taken of the length of the twigs to determine the relation between growth and vitality. Detailed meteorological records were also kept in connection with the work in an attempt to correlate growth and meteorological factors. There appears to be a periodicity in growth which is confined to a rather short time, during which the average growth was not much influenced by temperature or other weather conditions. The rest period begins early in July and after that time climatic conditions are without much effect. In the case of bearing apple trees the air temperature from day to day affects growth in individual cases. Leaf measurements were recorded, the results indi-

cating that large leaves store a large amount of reserve material and thus affect the formation of fruit buds. A much larger amount of starch was stored in twigs which had not produced fruit the previous year. Fruit-bud formation was increased by reducing the moisture in soil. Sod appeared to exert a depressing effect upon nitrification. Chemical analyses were made of different parts of the tree, and trees are dug up at different dates for the purpose of studying them in a dormant condition and before and after buds begin to swell. These analyses indicate periods at which the tree stores starch and mineral substances, and also where these materials are stored and at what period they are drawn upon for growth. The starch is rapidly used up during the swelling and opening of the buds.

A study of heredity in vegetables, particularly squashes and tomatoes, was greatly interfered with by the occurrence of drought and frost. In the project on carnation breeding also not much progress was made, most of the plants which were self-fertilized the previous year being lost. It was necessary, therefore, to start again with a first generation.

The project on water as a limiting factor in the production of corn was discontinued during the year. The method used in this investigation proved inadequate on account of the large amount of rain. Even the use of concrete walls, sunk $4\frac{1}{2}$ feet deep around plats, failed to prevent the seepage of water from one plat to another. It was found that the moisture content of the third foot of soil in the plats which received the most water was about the same as that in other plats. Studies of the availability of phosphoric acid and nitrogen in strong clay soils were practically completed. This line of investigation grew out of the study of potash availability. A new project was begun toward the close of the year for the purpose of determining the time in the life of cereals at which potassium should be applied to produce normal growth. Corn and wheat plants were used in this study, seedlings being grown in water cultures. Potash will be applied at different stages, and attention will be given to the transpiration of the experimental plants as well as to their absorption of potash.

The investigation of the effects of fungicides and insecticides on plants was concerned partly with the determination of the relative adhesiveness of sulphate of copper when sprayed on Coleus. One-half of each leaf is sprayed with sulphate of copper and the other with water. Considerable variation was observed in different applications. Physiological studies are also being made on the effect of Bordeaux mixture in stimulating tomatoes, beans, and radishes. The experimental plants are grown in pots in different percentages of soil saturation and under varying degrees of light intensity. Data

on sunshine, temperature, and relative humidity are recorded. It has been found that spraying increases transpiration. The gain in dry weight of the plants appears to depend on whether there is much or little water in the soil. The stimulating effect of Bordeaux mixture was found not to be due to shading. Water and sunlight appeared to be the important factors. Copper appears to be toxic to plants. Copper and ammonium hydrate mixture were found safer than copper and ammonium carbonate. Much difficulty was experienced in getting a satisfactory germination of the spores of parasitic fungi and the study of the toxic action of fungicides on these fungi was therefore not active during the year.

The project on sheep breeding moved forward with promising results. A study on the Mendelism of short ears in sheep showed that the short-ear trait is a clear example of a simple Mendelian unit factor. Diagrams are being made of the chest outline of the experimental animals. The lambs are measured biweekly up to the age of three months. Some observations have been made on the twin inheritance. A new system is being devised for selecting sires on the basis of family traits and nearly 100 fleeces were clipped this year and scoured to obtain data on inheritance of yolk and grease in the fleece. This study is carried on in cooperation with the Carnegie Institution.

Work with Hatch and other funds.—The forestry department maintained a series of plats for determining the rate of growth and fitness of certain exotic species under forest conditions and other plats for studying the growth of white pine between the ages of 5 and 15 years. Some attention was also given to problems concerned with the farm woodlot. In connection with the white-pine plats the gray birch is being studied with reference to its possible antagonistic effect upon the white pine.

The entomological work of the station included a study of the toxic effect of lead arsenate and experiments with the brown-tail moth and with grasshoppers. Much attention was given to the solubility of arsenate of lead in gastric juice in connection with its poisonous effect upon animals. The spray residues upon currant, strawberries, lettuce, cabbage, and blackberries will be analyzed. Thus far the toxic properties of lead arsenate in residues left on sprayed apples are less pronounced than was expected and apparently are negligible so far as human health is concerned. Good results were obtained in the control of the brown-tail moth by spraying in the spring with arsenate of lead. In accordance with the requirements of the State law some studies were made on the means of controlling grasshoppers, gypsy moth, and black flies. Attention was also given to the pine kermes.

The horticultural department continued its study of the blueberry industry. In this work data were collected from express companies

as to the amount of blueberries shipped from certain localities and a record was obtained of the yield of one blueberry pasture of 200 acres for a period of 15 years. Work was continued in testing varieties of apples, pears, and small fruits. An investigation was also begun of methods in use for the cold storage of apples. Further work along this line will be done. A study of cover crops was continued with reference to the depth of freezing and the soil moisture under cover crops.

The agronomy department conducted experiments on varieties of field beans and soy beans. Inoculation tests were made on soy beans without indicating much advantage from this operation. Some selection work was also done with flint corn, using the ear-to-row method. Fertilizer experiments on meadows have been continued for 9 years, using annual applications. During the year under report no fertilizers were applied, but the hay crops were carefully weighed to determine the residual effect of fertilizers. Nitrogen was the only element which gave appreciable effects. Fertilizer experiments with potatoes were concerned chiefly with a test of different sources of potash, phosphoric acid, and nitrogen and with the methods of applying these materials.

The chemical department, in cooperation with the other departments of the station, makes numerous analyses. The amount of miscellaneous analytical work demanded of the chemical department has been somewhat increased by the activities of county agents. An attempt is being made to hold this miscellaneous work within reasonable bounds. As in previous years, the official inspection of fertilizers and feeding stuffs occupied much of the time of the chemical department.

The botanical department is conducting experiments in the storage of potatoes with the object of devising means for preventing germination and the increase of sugar. It was found possible to prevent germination but no means has as yet been found for entirely preventing the increase in sugar. The potatoes were stored in a large galvanized iron vessel with calcium chlorid. Under these conditions the air became too dry and the potatoes lost greatly in weight. Other lots of potatoes were stored in an atmosphere containing a reduced amount of oxygen. In this case the loss in weight was somewhat less. Temperature appears to be the main factor in storage in the case of normal air.

The following publications were received from this station during the year: Bulletins 175, Analysis of Feeding Stuffs; 176, The Fertilizer Inspection for 1915; 177, Results of Seed Tests for 1915; and 178, Analysis of Feeding Stuffs.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch act-----	\$15,000.00
United States appropriation, Adams act-----	15,000.00
Farm products-----	725.83
Miscellaneous, including balance from previous year-----	8,677.81
 Total-----	 39,403.64

The New Hampshire station is feeling the pressure which results from the growth of the college and from the teaching duties required of the staff members. The station needs a liberal State appropriation. The work of the station is well administered and is organized with reference to the importance of State problems.

NEW JERSEY.

New Jersey State Agricultural Experiment Station, *New Brunswick*.
 New Jersey Agricultural College Experiment Station, *New Brunswick*.

J. G. LIPMAN, Ph. D., *Director*.

The work at the New Jersey stations proceeded along the same lines as in preceding years, accomplishing results of much importance. The demand upon the time of the director in connection with college work and other affairs connected with the operation of the stations is becoming increasingly heavy. One new building, a greenhouse laboratory (Pl. V, fig. 1) for the department of botany, was erected, at a cost of \$3,500. The equipment of the stations was further enlarged by the purchase of a farm of 35 acres to be used for experimental work in pomology and vegetable gardening. The resources of the station from State sources and fees were about \$120,000. A special appropriation of \$2,000 was made for the purchase of specimen types of live stock. Dr. J. Nelson, biologist since 1888, died on February 15, 1916.

Adams fund projects.—The project on the toxic effect of different amounts of salts on the development and structure of plants was continued, with special reference to seeds. In this work sulphates, nitrates, phosphates, carbonates, and chlorids were used in different strengths in nutrient solutions. The seeds were incubated in moist sand containing nine different concentrations and combinations of the chemicals. The amount of each chemical taken up by the plant is determined just before root hairs are formed. It appears that the amount absorbed decreases with the strength of the salt solution. Parallel experiments were made in soils and water cultures.

A study of inheritance and correlation of structural characters in hybrids was continued with corn, beans, eggplant, tomatoes, pep-

pers, and okra. Some of these plants are now in the fourth generation and a few of the strains have become quite well fixed. Attention is given to variation in leaves, stem, and fruit. Much effort has been devoted to an attempt to produce a large-fruited, thick-skinned tomato. A type with thick skin has already been obtained and this is being crossed with other types to obtain a better size and quality.

The influence of environment upon plant growth was studied, with particular reference to the effect of the location of the seed in the pod and to environment outside of the plant. Much attention was given to a study of the relative value of corn kernels from the middle, butt, and tip of the ear, and to the value of beans taken from various positions in the pod. Some work was also done with peanuts, selecting seed from different positions in the pod.

A large amount of work was done on the project relating to the availability of nitrogen in fertilizers. Timothy from plats treated in different ways was harvested and nitrogen determinations were made. Good success was had in growing wheat in cylinders treated with different fertilizers. A crop of barley and a residual crop of buckwheat were also grown in cylinders and results were secured as to nitrogen assimilation. Some of these cylinders have now been used continuously in experimental work for nine years.

The problem of accumulation and utilization of atmospheric nitrogen was studied in 320 cylinders, field plats, and also by means of pot experiments. Green-manure crops gave excellent results as a source of nitrogen in the cylinders. With few exceptions these crops proved superior to nitrate of soda used at the rate of 160 pounds per acre, and also to stable manure applied once in two years at the rate of 15 tons per acre. In the rotation field plats which received lime, the limed plats gave a larger yield than the check plats and produced a crop containing a higher percentage of nitrogen. The roots of soy beans grown on limed plats showed a larger number of nodules. A continuous wheat plat with a leguminous crop as a source of nitrogen yielded about twice as much grain as the corresponding plat without a legume.

Further progress was made in the study of sulphur oxidation. The citrate-soluble phosphoric acid set free by the use of sulphur in conjunction with raw rock phosphate was determined. In this experiment sulphur and raw rock phosphate are composted with soil for a period of six months. At the end of that time it was found that about 80 per cent of the phosphoric acid in the raw rock phosphate had become soluble. Apparently the rate of sulphur oxidation differs in different soils, depending upon the kind of organisms present in the soil. With one soil 98 per cent of the rock phosphate became available within 30 months.

About 45 species of soil bacteria were isolated and described from New Jersey soils in continuing the project on the investigation of the presence, distribution, and constancy of soil bacteria. Soils have also been brought from other States and examined for fungi and actinomycetes. A species of actinomycetes was found which apparently nitrifies ammonia. Some attention was given to methods of preparing media for the study of soil bacteria. The investigation of soil protozoa indicates that these organisms do not play an important part in the biology of the soil. A beginning was made in the study of soil fungi. Several species were isolated, and some of them have been studied with reference to their ammonifying power.

Work with Hatch and other funds.—The entomological department has studied the influence of atmospheric moisture upon insect metabolism; methods of controlling strawberry weevil, apple aphid, false cabbage aphid, and pear psylla; the efficiency of certain types of covers for wintering bees; the food preferences of house flies; and mosquito control. Decrease in atmospheric moisture appears to shorten the pupal period of the bean weevil and Angoumois grain moth. A diminution in atmospheric moisture also shortens the length of adult life in the case of the moth and lengthens it in the case of the weevil. The optimum atmospheric moisture for the bean weevil appears to be close to 100 per cent. Storage of beans in an atmosphere with a moisture content of 20 per cent or less protects them against the attack of weevils. In studying methods for the control of the strawberry weevil, the best results were had from dusting plants with a mixture containing one part powdered arsenate of lead and five parts of sulphur. Insecticide experiments with *Aphis sorbi* showed the best results from the application of a strong solution of lime-sulphur during the dormant period, followed by tobacco extract and soap in the spring. Experiments were made with a considerable variety of chemicals, including sugars, starches, dextrins, acids, and alcohols, to determine the food preferences of house flies. A large amount of work was done in studying the distribution and habits of mosquitoes, and in experiments with methods for controlling these pests. Tests were made of the insecticidal value of sodium hydrate, borax, copper sulphate, iron sulphate, lysol, phenol, and various mixtures in attempts to kill mosquitoes in the larval stage in water.

The department of plant pathology conducted experiments on the influence of sulphur on potato scab, the control of rot disease of celery, foliage diseases of tomatoes, fungicides for fruit diseases, the effect of Bordeaux mixture on transpiration of plants, and the influence of fungi on paints. In the study of root rot of celery it was found that steam sterilization of the soil, or the use of formaldehyde

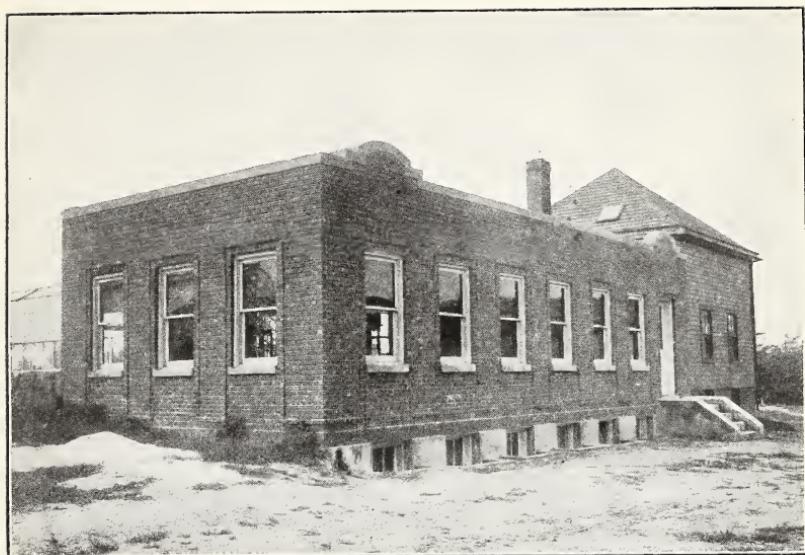


FIG. 1.—NEW GREENHOUSE LABORATORY, NEW JERSEY STATIONS.

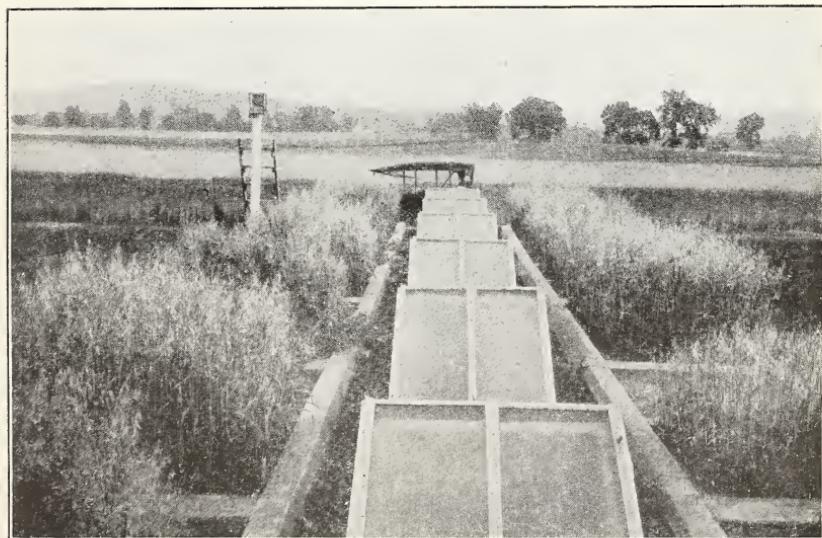


FIG. 2.—LYSIMETERS, NEW YORK CORNELL STATION.



and copper sulphate for the same purpose, may greatly reduce the disease. It appears that steam sterilization will cost about \$300 an acre, and treatment with formaldehyde about \$450 an acre.

The horticultural department conducted experiments in carnation and rose culture, breeding peaches, pruning experiments with peaches and apples, and fertilizer experiments with apples, pears, and peaches. It was found that the lack of sufficient humidity in the air of greenhouses caused American Beauty roses to be checked in growth and to lose their foliage. The plants also failed to develop growing shoots at the base when the humidity ranged from 60 to 70 per cent in winter. A high atmospheric humidity increased the size of the petals but not their number and tended to diminish the color of the flowers. Considerable attention was also given to methods of grading, packing, and shipping peaches; variety experiments with fruit trees; and cultural experiments with asparagus. In the pruning experiments with peaches each plat contained 15 trees and 3 varieties. The annual twig growth and trunk circumference are measured and the rate of pruning is determined. Similar experiments are under way in pruning apples. A study of cranberry culture, including fertilizer experiments and tests of methods of controlling and handling the water, is carried under a special State appropriation of \$1,500.

The animal-husbandry department has studied the cost of producing market pigs, the use of self-feeders as compared with the hand-feeding method for pigs, the relative palatability and yield of various forage-crop mixtures, and tests of various maintenance rations for brood sows, and began an experiment to determine the feeding value of garbage for pigs. Ground alfalfa hay, molasses, hominy, and tankage proved to be a suitable maintenance ration for brood sows. In experiments with the self-feeders it appeared that the system of free choice of feed shortened the growing and fattening period at least 60 days. The cost of a pound of gain during the preliminary stages, however, was somewhat higher. The use of the self-feeder method for brood sows with young pigs showed that the pigs gained thereby more rapidly and that fewer runts developed in the litter.

The work in poultry husbandry included a study of substitutes for sour milk for chicks, in which milk powder, milk albumin, granulated milk, and fresh skim milk were used. Some attention was also given to variability of pullets of the same breed and to the inheritance of barring patterns and colors in hybrids between Black Langshans and Black Hamburgs. A beginning was also made in an experiment to determine the influence of the pineal secretion upon the growth of young chicks.

A marked increase in the average milk production of the animals of the dairy herd was shown during the year. This increase was attributed to heavier feeding and to the elimination of unprofitable cows. The losses due to contagious abortion have been greatly checked. Several pure-bred animals were added to the herd during the year. It was found that the cost of milk production was greatly increased as the result of the high price of concentrates.

The agronomy department carried on two lines of work relating to farm crops and farm management. Variety tests were conducted with oats, corn, and wheat. Seed of the most promising varieties is produced in sufficient quantities for distribution among farmers for further cooperative experiments. Much attention was also given to the forage problem of the State. Experiments were conducted with different methods of seeding alfalfa, and also with timothy and Sudan grass. Farm management surveys were made in Monmouth County.

The following publications were received from this station during the year: Bulletins 276, The Mosquitoes of New Jersey and Their Control; 277, Humidity, Soil, and Fertility Studies with Roses; 278, Some Results in Size Inheritance; 279, Results of Seed Inspection, 1914; 280, Pot Experiments on the Availability of Nitrogen in Mineral and Organic Compounds; 281, Nitrogen Utilization in Field and Cylinder Experiments, II; 282, Factors Influencing the Protein Content of Soy Beans; 283, Concentrated Feeding Stuffs and Registrations for 1915; 284, Packing and Shipping Peaches in Georgia Carriers; 285, Analyses and Valuations of Commercial Fertilizers, Fertilizer Supplies, and Home Mixtures; 286, Analyses of Materials Sold as Insecticides and Fungicides; 287, Analyses and Valuations of Commercial Fertilizers and Ground Bone; 288, Investigations Relative to the Use of Nitrogenous Plant Foods, 1898-1912; 289, Cylinder Experiments Relative to the Utilization and Accumulation of Nitrogen; 290, Fertilizer Registrations for 1916; 293, Effect of Pruning Peach Trees at Different Heights Previous to Planting in the Orchard; Circulars 41, Varieties of Tree Fruits for New Jersey; 47, The Determination of Humidity in the Greenhouse; 48, Bordeaux Mixture; 49, The Management of the Farm Poultry Flock; 50, Common Diseases of Beans; 51, Diseases of Grains and Forage Crops; 52, The Common Diseases of the Pear; 53, Potato Diseases in New Jersey; 54, Improving Acid Soils; 55, Common Diseases of the Grape; 56, The Strawberry Weevil; 57, Asparagus; 58, Suggested Grades for Peaches; and the Annual Report for 1914.

The income of the stations during the past fiscal year was as follows:

State station:		
State appropriation	-----	\$84,900.00
Fees	-----	38,295.87
Farm products	-----	18,029.80
College station:		
United States appropriation, Hatch Act	-----	15,000.00
United States appropriation, Adams Act	-----	15,000.00
Total	-----	171,225.67

The New Jersey stations are maintaining close contact with their constituents and enjoy confidence to an extent which makes them a vital force for the advancement of agricultural science.

NEW MEXICO.

Agricultural Experiment Station of New Mexico, State College.

FABIAN GARCIA, M. S. A., *Director.*

The New Mexico station made advance in practically all of its projects. Additional room for feed storage was secured by an enlargement and rearrangement of an old building previously used for this purpose. Several changes occurred in the station staff. R. F. Hare, chemist, was succeeded by L. A. Higley; J. M. Mann, botanist, resigned and was succeeded by F. C. Werkenthin; R. L. Stewart was appointed agronomist to succeed E. P. Humbert. F. L. Bixby, who had charge of the cooperative irrigation investigations, was transferred by this department to carry on similar work at the University of Nevada. D. W. Bloodgood was appointed to this vacancy. A poultry department was organized, with R. B. Thompson in charge. The State legislature made an appropriation of \$5,000 per year, the first appropriation for maintenance which the station has received.

Adams fund projects.—The testing of the efficiency of turbine centrifugal pumps was somewhat interrupted with the withdrawal of the leader of this project. Experiments were made with two types of pumps and two other types were to be used in further testing. Nearly 200 tests are made on each pump. A large mass of data has thus been accumulated regarding the efficiency of turbine pumps.

A study of the relation of soil water and crops in irrigation continued with encouraging results. The water applied in these experiments has been carefully measured and soil samples were taken at frequent intervals to learn the fate of the irrigation water within the zone of the plant. In this work samples are to be taken on 1, 2, 4, 7, and 10 days after irrigating. The samples were taken every foot for a depth of 10 feet and 48 additional plats are sampled every 10 days to a depth of 6 feet. Some of the alfalfa plats were

fallowed, others cropped and cultivated, and still others fallowed and uncultivated. These experiments are conducted on the mesa plats on first bench land adjacent to the Mesilla Valley.

The nutritive effect of important feeds for range steers received a large amount of attention. During the year 2 and 3 year old steers were fed cottonseed meal and chopped alfalfa hay. After a period of 120 days the animals were slaughtered and careful notes taken on the effects of the feeding. The carcasses of certain representative animals from each lot were analyzed to note the location of the fat and other stored material. It was planned to calculate the results on an energy basis. Another lot of steers was fed entirely on farm crops, receiving cowpeas to balance the ration properly. The roughage for this lot was Kafir corn, silage, and milo maize. The results were in favor of cowpea hay.

The project on the improvement of Mexican chili by breeding and selection was largely restricted to two strains, the others being gradually eliminated. These two strains are being planted on a large scale. The work has thus far been along the line of selection. Considerable improvement has been made in smoothness and fleshiness of pod. A study of the organism causing chili blight was greatly interfered with during the year on account of difficulties with apparatus and arrangements in the greenhouses where the work was in progress.

The project on the life history of the codling moth in New Mexico was carried forward actively. The laying periods of hibernating codling moths were studied with particular reference to the percentage of hatching of the eggs as determined by climatic conditions. It has been found that the life history of the codling moth is sufficiently different in New Mexico from that reported in eastern States to necessitate a different calendar for spraying operations. Careful detailed records were kept of the appearance of the different broods of the insect in an open shelter under outdoor conditions. Particular attention was given to records of the first and second broods.

Further work was done in attempting to learn the reason for the failure of potato tubers to develop properly. It has been found that the plant grows vigorously, but does not store up starch in the tuber. This was thought to be due to climatic conditions. The investigation was carried on in both the field and greenhouse, the latter being provided with dry and humid sections. Thus far no effect of humidity has been demonstrated. In the field 84 plats were maintained, one-half of them being manured. It is planned to determine the effect of fertilizers upon the storage of starch and the development of the tuber.

The investigation of alkali and plant food under irrigation conditions was continued in 12 tubes of galvanized iron 4 inches in diameter and about 7 feet long. All the tubes are irrigated at the same time, but with different amounts of water. After a certain number of applications have been given, the tubes are taken apart in joints 1 foot long and the soil samples examined.

Work with Hatch and other funds.—The division of biology conducted experiments on the life history and control of peach worm, grasshoppers, San Jose scale, garden insects, and also investigated a number of plant diseases. Considerable success was had in the use of poisoned baits and hopper-dozers for controlling grasshoppers and from lime-sulphur sprays in combating San Jose scale. The introduction of ferrous sulphate into holes bored in chlorotic pear trees gave no indication of benefit, and similar negative results were obtained from spraying the trees with a 1 per cent solution of ferrous sulphate. Observations were also made on pear blight and root rot of alfalfa and fruit trees.

The chemical division began some experiments on sugar beets. The preliminary results were quite encouraging. A comparative test has been made on fall and winter planting. This work is to be carried on under a cooperative arrangement with certain farmers.

The work of the horticultural division included a wide range of experiments such as phenological observations on grapes and peaches, pollination of pears, tests of orchard cover crops, cultural experiments with celery, cabbage, cauliflower, strawberries, blackberries, raspberries, pecans, and walnuts. In the pollination experiment it was found that the flowers of the Bartlett pear tree when prevented from being cross-pollinated developed only about one-third as many fruits as normally exposed trees. In studying the affinity between apple buds and pear stock it was found that the union between the pear stock and the apple scion showed no noticeable weakness. Some attention has also been given to a determination of the value of smudging in frost prevention. The stump versus trellis system is also being tried with grapes. In a test of peas as a green manure and cover crop for orchards a number of varieties of peas, including sweet peas, were used. The vines of the sweet pea proved to be more resistant to cold during winter than the common varieties of field peas. There was no material difference in the resistance to cold of the different varieties of field peas used in the experiment. In a study of methods of protecting grapes in winter it was found that the vinifera grape was not as resistant to winter temperatures as native varieties, but that it could be readily protected by banking up the soil around the vines.

The agronomy division conducted rotation experiments, variety tests with cereals and sorghums, and cultural experiments with corn, wheat, sugar beets, and Sudan grass. The rotation experiments have been in progress for six years. The cultural experiments with wheat included a study of the dates and rates of seeding and also of the water requirements of wheat. Better results were obtained with Sudan grass and from planting in rows than from broadcasting.

The work in animal husbandry included experiments in feeding pigs, calves, dairy cows, lambs, and poultry. In feeding dairy cows it was found that silage in the ration may take the place of much of the higher priced alfalfa hay, probably to the extent of one-half. Silage under such conditions diminishes the cost of production. When pasture was available for most of the year silage seemed not to hold a very important place in the ration of dairy cows. In pig-feeding experiments it was shown that it is more profitable to feed a heavy ration of concentrates, at least 2 pounds to 100 pounds live weight, than a light or a medium ration for hogs supplied with an abundance of alfalfa hay. When fed in connection with alfalfa hay ground corn gave better results than skim milk supplemented with shorts and bran. An experiment is also in progress to determine whether there is more profit in keeping calves and feeding them until they are 18 to 21 months old or in fattening them at once and selling them as baby beef. A pasture experiment with dairy cows was also carried on. A lamb-feeding experiment has been planned to secure data on the most economic and satisfactory rations for New Mexico conditions. The poultry work was reorganized under the support of a State appropriation and a number of practical experiments have been planned.

The following publications were received from this station during the year: Bulletins 94, The Grape Leafhopper; 95, Probable Combinations of the Chlorine Ions in Alkali Salts—A Review and Discussion of Some of the Methods for the Determination of Alkali in Soils; 96, Alfalfa Hay for Hogs; 97, Tests of Submerged Orifice Headgates for the Measurement of Irrigation Water; 98, Economic Feeding for Milk Production in New Mexico; 99, Peas as an Orchard Green Manure and Cover Crop; 100, Winter Protection of the Vini-fera Grape; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
Farm products, including balance from previous year-----	8,572.19
Total -----	38,572.19

The work of the New Mexico station has been further improved and strengthened and was not unduly retarded by the changes in the personnel of the staff during the year. The station is coming in closer contact with the farming population and is a forceful factor for agricultural development. The new State appropriation is an added factor of strength and encouragement.

NEW YORK.

Cornell University Agricultural Experiment Station, *Ithaca*.

B. T. GALLOWAY, LL. D., *Director*.

The year was a somewhat unsettled one at the Cornell station. B. T. Galloway resigned as director, and was succeeded by A. R. Mann as acting director to assume his duties in July, 1916. The legislature placed all expenditures of the institution on a budget plan, making appropriations for specific amounts to specific purposes and not permitting any transfer of funds or elasticity in the budget. The Cornell station receives no direct State appropriation for station work, but considerable amounts from the general appropriation of the college are used for experimental purposes. No new buildings were erected during the year. Additions and improvements were made in greenhouses, tool barn, and sheep barn.

Adams fund projects.—The investigation of inheritance in hybrids included work on corn and beans. With corn attention was devoted largely to the inheritance of color. Much effort has been spent in the study of the interrelation of genetic factors. A simple form of inheritance of 25 or more factors has been worked out and in a few cases linkages of factors have been determined. In the course of this work careful studies have been made of 2,700 pedigree cultures of corn, 1,100 of oats, 400 of wheat, and smaller numbers of barley, morning glory, and phlox.

Mutation and other types of variation in wild and cultivated plants received much attention. This work was carried on largely with pure lines of phlox, potatoes, and timothy. Some attention was also given to clover and alfalfa. Selection was continued within pure lines of wheat, oats, beans, and potatoes to determine whether there is a cumulative effect of long selection. Bud variations in color, size, and shape of potatoes are also under study.

The influence of an environment in producing variations was studied on three types of soil, with particular reference to wheat. Wheat was grown on soils widely different in type and fertility and also under different climatic conditions at Ithaca and at Columbia, Mo., in cooperation with the Missouri station. Similar observations were made on oats at Ithaca and at the Montana station. Field

daisies were also cultivated in the garden and studied under normal conditions in the field. Thus far little permanent effect of diverse environment has been observed.

The project on soil technology involves largely a study of the factors which influence the formation of nitrate (Pl. V, fig. 2). It appears that certain crops inhibit nitrification to some extent. More nitrogen was obtained in the drainage waters from certain unplanted tanks than was secured from the plants on planted tanks plus that in the drainage waters from these tanks. This is interpreted as meaning a loss of available nitrogen, which it is assumed has been transformed into organic nitrogen. Corn and certain other plants were found to exert a stimulating effect on the production of available nitrogen. Attention was also given to the effect of solutions in which plants have been grown, upon the rate of ammonia formation, and nitrate reduction. It was found that the liquids in which plants grew exercised a striking influence on the fermentation processes. Changes in the concentration or the composition of the nutrient solution exercised little effect on fermentation. This investigation has led to a study of the possibility of the secretion of enzymes by plants. Timothy, for example, reduces nitrates nearly as fast as they are formed. It is believed that this may account for the bad effects of sod in young orchards.

Work with Hatch and other funds.—The entomological work included a study of locusts, hop insects, clover pests, apple aphid, poplar borer, pine-leaf scale, miscellaneous apple pests, fruit-tree leaf-roller, scale insects, the army worm, and a comparison of dust and liquid sprays. Important contributions were made to the knowledge of the life history and habits of these pests. It was found possible to control the poplar borer (*Cryptorhynchus lapathi*) by the use of carbolineum. The eggs of the fruit-tree leaf-roller are quite effectively destroyed by thorough spraying with miscible oils. In a comparison of dust and liquid insecticide treatments it was found that a reduced quantity of arsenate of lead in a dust mixture may be depended upon to give good results. The codling moth was more effectively controlled by dusting than by the use of liquid sprays. No indication was obtained that dust mixtures are improved by the addition of any diluents.

The work of the forestry department involved a study of the preservation of fence posts, forest reproduction, and utilization of woodlots. Fence posts made of beech, yellow birch, maple, cherry, elm, basswood, and hemlock were treated by brushing with creosote, dipping in hot creosote, and by the open-tank creosote process. The treatment of brushing required the smallest amount of preservative. The results of the experiment will not be known for some time. Considerable attention was given to a study of the differences in

young growth in fenced and unfenced areas, and also to methods for the economic utilization of farm woodlots.

The crop-breeding work of the station was continued with oats, wheat, barley, corn, beans, potatoes, and timothy. In this work about 4,000 rows and 2,000 larger plats of cereals were under observation. Selected strains of oats and wheat gave yields of 3 to 10 bushels more per acre than the varieties from which they were derived. Timothy selections continued for a period of five years have yielded over 1 ton per acre more than ordinary timothy. Similar results were obtained with potatoes and corn.

A wide range of work in plant pathology was carried forward during the year involving studies of peony diseases, the relation of vigor of plants to disease, timothy smut, *Gymnosporangium* rust, bean anthracnose, *Fusarium* wilt of potatoes, blister rust of pines, and other fungus and bacterial diseases. A monograph of *Botrytis* is being prepared based on forms of *Botrytis* from more than 300 sources and from more than 75 host plants. All of these forms have been grown and studied in cultures and inoculation experiments have been made on a number of hosts. In the investigation of bean anthracnose it was found that there is more than one strain of the causal organism. A dust mixture of finely ground sulphur and arsenate of lead gave the best results in controlling the leaf-blotch disease of horse-chestnut. Considerable attention was given to diseases of buckwheat, maple, linden, witch-hazel, and other fungus diseases of trees and shrubs.

The pomological department conducted studies of osmotic pressure in fruit trees, hardiness of the peach, plum, persimmon, and English walnut, fertilizers for bush fruits, pruning old orchard trees, color relations of fruit, and the causes of the June drop of fruit trees. It was learned that the roots of the blackberry and red raspberry are very susceptible to cold, being killed by a temperature of -8° C., while the roots of the gooseberry and currant will withstand temperatures of -17° C. With regard to the color of fruits it has been found that the complete exclusion of light does not always prevent the development of color, but may delay maturity.

A large amount of work was also done on various phases of vegetable gardening, including the fertilizer requirements of tomatoes, types and varieties of celery, maintenance of fertility of muck lands, spacing of tomatoes in greenhouses, and training cucumbers for greenhouses. An attempt is being made to discover the most feasible method for maintaining the nitrogen supply in muck soils for crops of celery, lettuce, and onions.

The dairy investigations included a study of the nutrition of the dairy cow, the effect of centrifugal clarification upon the germ content and keeping quality of milk metallic flavor in dairy products,

and methods of making some of the soft cheeses. It was found that while the direct absorption of metals may cause a metallic flavor in dairy products, the same flavor may also be produced by bacteria. In 241 samples of cream kept in sterilized glass bottles, the metallic flavor was produced in 79 samples by inoculation with buttermilk possessed of a metallic flavor. The organism causing metallic flavor was identified as a strain of the *Bacterium lactis acidi* group.

The poultry studies involved an investigation of inheritance of fecundity, egg characters and constitutional vigor, in-and-in breeding, relation of ear-lobe color to color of the eggshell, and various other breeding problems. Some attention was also given to a study of the efficiency of various types of trap nests and to the influence of turning eggs during incubation upon the hatching of the eggs and the development of abnormalities in chickens. More than 1,000 fowls were used in this experimental work.

The farm-management studies during the year were largely confined to cost accounting and to a study of cost of producing milk. As the result of an elaborate study of milk production on 174 dairy farms in Delaware County, it was found that the average loss per cow ranged from \$12.50 to \$32.14 per year. This is interpreted as meaning that hay and other forage was fed to cows for a return less than its actual farm value and that farmers accepted a smaller return for their work than standard wages and were content also to accept for their whole investment a lower rate of interest than 5 per cent.

The general soil studies of the station included an investigation of the influence of soil moisture on the availability of plant nutrients, conditions under which lime is removed from soil, nitrogen balance under timothy and alfalfa, chemical composition and physical properties of important types of soil, fertilizers for timothy, comparative experiments with acid phosphate and rock phosphate, experiments with different forms of lime, continuous cropping without manures, and the value of nitrate of soda applied to timothy. The formation of soluble nitrogen was found to be readily affected by the percentage of moisture in the soil. Some evidence was obtained that the better growth of crops following a legume may be due to the greater availability of the soil nitrogen after that crop rather than to the higher percentage of nitrogen.

The following publications were received from this station during the year: Bulletins 283 (rev.), The Control of Insect Pests and Plant Diseases; 361, The Home Grounds; 362, Soil Survey of Oneida County, New York; 363, Phytophthora Disease of Ginseng; 364, Cost of Producing Milk on 174 Farms in Delaware County, New York; 365, The Taxonomic Value and Structure of the Peach-leaf

Glands; 366, Woodlot Conditions in Broome County, New York; 367, The Fruit-tree Leaf Roller; 368, Woodlot Conditions in Dutchess County, New York; 369, Dusting and Spraying Experiments with Apples; 370, Forest Legislation in America Prior to March 4, 1789; 371, The Leaf Blotch of Horse-chestnut; 372, Reports on Scale Insects; 373, Metallic Flavor in Dairy Products; 374, Reforesting Methods and Results of Forest Planting in New York State; 375, Possibilities of Private Forest Management in New York State; 376, The Army Worm in New York in 1914; Circulars 29, Poultry Parasites—Some of the External Parasites that Infest Domestic Fowls, with Suggestions for their Control; 30, Methods of Making Some of the Soft Cheeses; 31, Fall Spraying for Peach Leaf Curl; 32, Dusting Nursery Stock for the Control of Leaf Diseases; Memoirs 6, Fusaria of Potatoes; 7, Senile Changes in Leaves of *Vitis vulpina* and Certain Other Plants; 8, A Bacterial Disease of Stone Fruits; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$13,500.00
United States appropriation, Adams Act-----	13,500.00
State appropriation-----	53,324.90
Fees -----	5,888.23
 Total-----	 86,213.13

The Cornell station continues to perform a large amount of high-grade research work, much of which is of direct practical importance to the agriculture of the State. All of the work of the station is carefully organized on a project basis, thus making possible the maintenance of accurate records from year to year.

New York Agricultural Experiment Station, Geneva.

W. H. JORDAN, D. Sc., LL. D., Director.

The legislature at its last session appropriated \$100,000 for the erection of an administration building for the station, to contain mailing rooms in the basement, the director's office, accounting office, and library on the first floor and assembly rooms on the second floor. A strong need had been felt for an auditorium or assembly room in which meetings of farmers might be held. A. W. Bosworth, associate chemist, resigned, and E. J. Lewis was appointed assistant chemist. A. J. Mix was appointed assistant botanist during the absence of N. T. Munn on a year's furlough for post-graduate work.

Adams fund projects.—The study of important factors in the production of sanitary milk was continued in a satisfactory manner.

The investigation of the effect of the relation of barn dust to milk sanitation was completed and published. When the effect of leaving 5 liters of milk standing in an open 12-inch pail in the open stable was calculated, it was found that the numbers of bacteria thus added ranged from 96 to 199 per cubic centimeter. This increase is so small that it would not be detectable in ordinary milk by the usual methods of bacteriological analysis. It was found that in the stable loft, when a heavy dust was raised by sweeping up the débris on the floor, the germ content of the air was usually between 1,000 and 2,000 per liter. When sterile water was milked through a special device under these dusty conditions it was found to have acquired an average germ content of 47 per cubic centimeter. It appears, therefore, that the number of organisms which find their way into milk from stable dust is so small as to be negligible. This investigation is carried on in cooperation wth the Illinois station, where particular attention is given to the milk can and other utensils as sources of bacterial contamination. Work was also continued on methods of counting bacteria. Apparently neither the microscope nor the plate methods of counting can be made absolutely accurate but a combination of both methods usually gives reliable results.

Considerable progress was made in the study of the acidity of milk. The amount of free acid in sour milk apparently can not be determined at present. The hydrogen ion concentration gives a satisfactory means of determining it. This method will be used in further work along this line. Fresh milk was analyzed for its soluble and insoluble constituents, using a porous porcelain filter for separation. Another portion of the same milk had been inoculated with a culture containing lactic-acid bacteria. At the end of 60 hours, determinations were made of the soluble and insoluble portions. About 22 per cent of the milk sugar was transformed by the lactic-acid bacteria, 88.5 per cent of the amount so changed being converted into lactic acid. It was found that when the amount of lactic acid reaches 0.7 per cent the bacterial activity is much reduced. The acidity increases most rapidly during the first 24 hours.

It is planned to continue the study of metabolism and physiological effect of phosphorus bodies in feeding stuffs in connection with poultry. In this work a respiration apparatus will be used.

Work with Hatch and other funds.—The bacteriological division conducted work on soil bacteria, methods of counting bacteria by means of the microscope, the spore-forming bacteria of soils, the function of actinomycetes in the soils, and the pasteurization of dairy by-products. On the basis of these studies, soil bacteria were classified in three groups—spore forming, nonspore forming, and actinomycetes. The forms of actinomycetes were found more abundant in sod than in cultivated soil, the ratio varying from 2:1 to 6:1. Actino-

myces constituted about 38 per cent of the total flora of the sod soil but only about 20 per cent of the flora of cultivated soil. Some evidence was obtained that actinomycetes is active in the decomposition of grass roots. The number of spore-forming bacteria in soils was found to be relatively constant and about the same in all soils under observation. When soil infusions were heated before plating, at a temperature of 75° to 85° C., at which all vegetative forms of bacteria were killed, nearly as many colonies of spore-forming bacteria developed as without heating. No increase in the total number of organisms nor decrease in their spores could be detected in a pot of soil to which fresh manure had been added. The value of these organisms as ammonifiers is therefore somewhat thrown in doubt.

Of the 950 cheese factories in the State, about 55 pasteurized their whey. At most of these factories the temperatures used in pasteurization were found to be high enough to meet the requirements usually specified by law. It was found that the process of heating the whey aided in preserving it in good condition until it was convenient to use it. The heating of the whey killed all organisms which ordinarily caused fermentations except *Bacillus bulgaricus*. Pasteurized whey was found to be free from yeasts.

The entomological division conducted work on tree crickets, plant lice, leopard moth, sawfly, leaf miners, cabbage aphid, grape root-worm, pear borer, and other insect pests. The light-colored blister-like areas noted in recent years on the leaves of sour cherries were found to be caused by a leaf-mining sawfly (*Profenus collaris*). This pest had not been previously recorded from the State. The life history and habits of the insect were carefully studied. It is attacked by two parasites, but is not effectively controlled by spraying with lime-sulphur, kerosene emulsion, or miscible oils. The life history and habits of tree crickets were carefully worked out and a monographic account of this group of insects was published with particular reference to their identification and their economic importance.

The horticultural division has completed a manuscript on the peaches of New York. Work was continued on variety testing and breeding of various fruits as well as in pruning experiments and the use of orchard fertilizers. In a study of inheritance of certain characters of grapes it was found that many of the commercial varieties failed to transmit desirable qualities. In this work about 3,000 self-pollinated pure seedlings were grown. These seedlings almost uniformly lacked in vigor. Of the two types of stamens, reflex and upright, the first type appears to be correlated with complete or nearly complete self-sterility.

As a result of a 10-year's study of dwarf apples in orchards under varying conditions, it appears that dwarf apple trees can not be

recommended for the commercial grower. They come into bearing little if any earlier than standard trees and produce too low a yield. Much attention was given to a study of the blooming season, the ripening dates, and the length of season for various hardy fruits in the State, and observations were made on a number of important new varieties of fruit considered worthy of further trial in the State. Cultural experiments were also conducted on sweet corn, strawberries, currants, raspberries, blackberries, tomatoes, gooseberries, and dahlias.

The agronomy investigations included a study of the limestones of New York with reference to their agricultural use, and experiments with alfalfa. The limestones of the State were carefully studied and a bulletin was published giving a description of each of 49 limestone formations in New York. Some work was carried on with lysimeters in an attempt to determine whether capillarity brings up plant food from the lower reservoirs of the soil. Shallow feeding plants are grown in these lysimeters, while other cylinders are maintained for studying the influence of legumes in adding to the supply of soil nitrogen. Alfalfa is used in these experiments and the results obtained with alfalfa are checked by the use of timothy. Some attention is also being given to the lime requirements of soils. It has been found that about three-fourths of the farm lands of the State are so deficient in carbonate of lime as to be poorly adapted for the use of growing alfalfa. The botanical division carried on experiments in breeding cantaloups, breeding peas for canning purposes, and also some work in orchard breeding. The stem rot and leaf spot of clematis were carefully investigated and found to be caused by *Ascochyta clematidina*. The fungus grows down through the petiole into the stems and girdles the plant at the node, thus causing its death. The fungus is not killed by winter temperatures. A dense growth of foliage on clematis plants appears to be most favorable for the spread of the disease. The removal of diseased leaves and vines before spraying and the application of the usual fungicides served to control the disease.

The chemical division in addition to its usual analytical work in connection with the inspection of feeding stuffs and fertilizers carried on an investigation of human milk and of the casein and salts of goat's milk. It was found that the idea which has prevailed as to the difference in acid reaction in human milk and cow's milk is erroneous. Apparently the high acid figures previously obtained for cow's milk were due to the interference of the neutral calcium phosphate which was present in cow's milk but not in human milk. Careful experiments indicated that the acidity of human milk and cow's milk is practically the same. The acidity of goat's milk was found to be considerably less than that of cow's milk. The quantity

of salts and the number of different salts in human milk appears to be less than is the case with cow's or goat's milk, while the phosphates in goat's milk seem to be combined with more bases than in the other milks.

The following publications were received from this station during the year: Bulletins 406 (with popular edition), Dwarf Apples; 407, The Blooming Season of Hardy Fruits; 408, Ripening Dates and Length of Season for Hardy Fruits; 409 (with popular edition), Germ Content of Stable Air and Its Effect upon the Germ Content of Milk, I and II; 410, Report of Analyses of Samples of Commercial Fertilizers Collected by the Commissioner of Agriculture During 1915; 411 (with popular edition), The Cherry and Hawthorn Sawfly Leaf-miner; 412 (with popular edition), The Pasteurization of Dairy By-products; 413, Director's Report for 1915; 414, New or Noteworthy Fruits, IV; Technical Bulletins 42, The Tree Crickets of New York—Life History and Bionomics; 43, Human Milk; 44, *Ascochyta clematidina*, the Cause of Stem-rot and Leaf-spot of Clematis; 45, Inheritance of Certain Characters of Grapes; 46, The Casein and Salts of Goat's Milk; 47, Limestones of New York, with Reference to their Agricultural Use; 48, Chemical Changes in the Souring of Milk; 49, Counting Bacteria by Means of the Microscope; 50, Tree Crickets as Carriers of *Leptosphaeria coniothyrium* and Other Fungi; 51, Are Spore-forming Bacteria of Any Significance in Soil under Normal Conditions; 52, A Possible Function of Actinomycetes in Soil; 53, The Number of Colonies Allowable on Satisfactory Agar Plates—A Comparison Between Agar and Gelatin as Media for the Plate Method of Counting Bacteria; Circulars 28, Distribution of Station Apples; 29, Culture of Sweet Corn; 30, The Cabbage Aphis; 31, Strawberries; 32, Currants; 33, Raspberries, Blackberries, and Dewberries; 34, Tomato Culture; 35, Hot and Cold Frames; 36, Culture of the Potato; 37, Second Distribution of Station Apples; 38, Rhubarb Culture; 39, Alfalfa on Land not Naturally Adapted to that Crop; 40, Onion Culture; 41, The Grape Rootworm; 42, Guide to Buildings and Grounds; 43, Dahlias and Their Culture; 44, Sinate Pear-Borer and Leopard Moth; 45, Soy Bean and Cowpea; 46, Gooseberries; 47 Plant Foods for Crops in 1916; 48, Culture of Cabbage; and the Annual Report for 1914, parts 1 and 2.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$1,500.00
United States appropriation, Adams Act-----	1,500.00
State appropriation, including balance from previous year-----	108,171.36
 Total-----	 111,171.36

The New York State station is maintaining its record for high-grade research work. Year by year results of large and immediate practical importance are brought forth. Its work is well organized and has in view the special agricultural problems of the State.

NORTH CAROLINA.

North Carolina Agricultural Experiment Station, *Raleigh.*

B. W. KILGORE, M. S., *Director.*

The station has placed all of its work upon a project basis, about 100 projects being actively pursued with Federal and State funds. Several other lines of investigation are conducted wholly or in part by the State department of agriculture in cooperation with the station. Nearly 200 acres of land are used for experimental work, chiefly in the departments of agronomy, animal husbandry, and horticulture. H. R. Fulton, plant pathologist, resigned and was succeeded by F. A. Wolf. Additional buildings to the value of \$2,500 were erected in connection with poultry and tobacco investigations.

Adams fund projects—The study of apple and lettuce diseases was continued actively. The apple diseases under investigation are tree rots. Already three or four organisms have been isolated and are under study. Since none of them has fruited, their specific identification is not yet possible. One of the species grows readily on artificial media and inoculation with mycelium produces the typical root rot. In continuing the investigation of lettuce diseases, evidence was obtained indicating the nonidentity of species of *Sclerotium* which appear on lettuce and clover. Further work is to be done on the life history of these fungi and on natural means of dispersion.

Further work was done on nitrification, chiefly with reference to the electrical conductivity of solutions as a means of determining the extent of nitrification. A number of formulas have been tested using different proportions of various chemicals which have been inoculated with pure cultures. In these tests the loss of nitrogen was determined.

The relation of geology and chemistry of soils to productivity and fertilizer requirements received much attention. A series of pot experiments was started parallel with field observations. A large mass of data has been accumulated containing the results of chemical and petrographic determinations of soils in several parts of the State. In general, after sufficient nitrogen has been supplied, phosphoric acid appears to be the most important limiting factor except in the southeastern portion of the State, where potash is of most importance.

In connection with the study of the transmission of characters in hybrids of *Rotundifolia* grapes, attention was given also to problems

of plant sterility and to the investigation of double flowers and sterility in blackberries and dewberries and to seedlessness in persimmons. The cause of sterility in the blackberry and dewberry has not been definitely determined, but it has been found that interplanting with self-fertile varieties offers a means of control. In the case of Muscadine grape the transmission of color, productivity, and size of bunches has been studied and a number of crosses have been made for further observation. In the self-sterile forms of the Muscadine grape no pollen is formed in the anther cells.

Further progress is made in the study of the toxicity of cottonseed meal to swine. During the previous year gossypol was isolated and evidence presented indicated it to be the toxic agent. Further experiments tend to substantiate that conclusion. After gossypol was extracted from the seed it was found that the seed were no longer toxic to rabbits, while the extract was toxic. Experiments in determining the value of iron sulphate as an antidote for gossypol poisoning in swine were interfered with by the occurrence of parasites. Some benefit was noted from feeding iron sulphate, but better results were obtained from citrate of iron and ammonia. Further studies will be made on the composition of gossypol.

Work on the life history of the gloomy scale proceeded satisfactorily. The hard maple appears not to be subject to the attack of this insect, and it is recommended, therefore, that it be planted in place of the soft maple. Satisfactory means of controlling the gloomy scale have been found in miscible oils. An attempt is being made to determine the nature of immunity in the case of the hard maple and also the reason for the greater effectiveness of miscible oils as compared with lime-sulphur in controlling the pest. A beginning was also made on a study of the life history of three species of *Bruchus*, one of which attacks beans and garden peas, while the other two attack cowpeas. It has been found that the use of air-slaked lime in storage will satisfactorily control these pests.

The projects on the genotypic constitution of cotton varieties and place variation of cotton were conducted in close connection. A large number of individual plants are being studied in detail and photographic and mathematical records are kept of the different characters. The study of place effect on cotton is carried on cooperatively by the North Carolina and Mississippi stations. An exchange of seed was made in 1915. Data are recorded regarding number and date of blooms, yield and character of lint, and many other features. During the year the Mississippi seed gave more and slightly earlier blooms than the North Carolina seed, but the differences were slight.

Work with Hatch and other funds.—The department of agronomy continued its soil-survey work in cooperation with this department

and also studied problems of soil fertility in 17 localities, representing different types of soil. In cooperation with this department a tobacco experiment, involving 20 acres of land, is also under way. This work includes tests of fertilizers, varieties, rotation systems, methods of planting, and effect of leguminous crops on tobacco. Plant-breeding work is carried on particularly with cotton, corn, wheat, oats, soy beans, and clover. Special attention was given to soy beans which is becoming an important crop in the State. A comparison of different dates of seeding wheat showed a progressive decrease in yield from the sowing on October 10 to that on December 21. Some experiments were also made on the use of lime and on drainage and means of preventing erosion.

The department of plant pathology studied the problem of tobacco wilt, with particular reference to the control of this disease by means of rotations. It has been found that the bacterial disease of the tomato is due to the same organism as that which causes tobacco wilt. Peanuts are also affected by the same disease. A beginning has been made on the study of methods of controlling chestnut blight, cotton anthracnose, and Fusarium of watermelon.

A reorganization was effected in the department of animal husbandry, bringing several lines of work into closer relation. Further experiments were conducted on the effect of feeds, especially peanuts and soy beans, upon pork. About 300 samples of meat were analyzed in connection with this work. Other experiments involved a test of the value of southern crops for pork production, feeding cottonseed meal to young cattle, fattening experiments with steers, and sheep breeding.

The poultry experiments included a study of the effect of cottonseed meal on egg production, feeding experiments with ducks, turkeys, and chickens, and problems involved in the incubation of eggs. It was found that cottonseed meal in dry mash, constituting 10 per cent of the mixture, showed no noticeable effect on laying and breeding fowls for a space of 90 days. When, however, cottonseed meal constituted 20 per cent of the fattening ration, the fowls showed a loss of appetite and in some cases a loss of weight. Injurious effects were noted from cottonseed meal in feeding fowls when it was fed to the extent of 1 ounce or more per day. Buttermilk or sour milk was found to be beneficial in feeding young chickens as soon as they were taken from the incubator. Attacks of diarrhea were largely prevented and more rapid gains in weight were made.

The dairy department conducted experiments in feeding cottonseed meal to cows, preventing onion flavor in dairy products, feeding silage to dairy cows, and the manufacture of buttermilk cheese. It was found that the flavor of wild onions appears in the milk within 20 to 45 minutes after feeding. Various methods are tried for

eliminating this flavor and aeration gave somewhat encouraging results. A study is also in progress to determine the cost of producing market milk and of raising dairy cows. The department of entomology carried on experiments in the control of insects on potatoes and orchard trees. Particular attention was given to laundry soap as a remedy for aphids and to spraying methods for the control of curculio. The division of horticulture conducted cultural experiments with the sweet potato, cantaloup, cabbage, Irish potato, strawberries, green corn, lettuce, and pecans. The work of the veterinary division involved cooperation with a number of other departments and inspection of dairies under State funds.

The board of agriculture conducts a large number of experiments partly in cooperation with the station. This work involves entomological surveys and inspection work, variety testing of fruits on State farms, breeding experiments with pecans, studies of thermal fruit belts, and of the storage of sweet potatoes, cabbage, and other vegetables. The work of the division of marketing is largely an extension enterprise, but some experiments are under way relating to problems of storing, packing, and shipping produce.

The following publications were received from this station during the year: Bulletins 230, Variety Tests of Corn in 1914; 231, Report on Variety Tests of Cotton for 1914; 232, Results of Variety Tests of Wheat, Oats, and Rye; 233, Common Diseases of Poultry; 234, Farm Drainage in North Carolina; 235, Some Further Studies of Chick Mortality—When to Feed the Baby Chick; 236, The Prevention and Control of Erosion in North Carolina, with Special Reference to Terracing; Circulars 24, Soy Bean Pasture for Hogs; 25, Feeding the Sow and the Suckling Pigs; 26, Pig-club Manual; 27, The Limitations of Cottonseed Meal Feeding in Poultry; 28, Use of Lime on the Farm; 29, Feeding Skim Milk, Buttermilk, and Whey to Hogs; 30, Oats for North Carolina; the Annual Report for 1915; and the Biennial Report for 1913-14.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	89,240.51
Farm products	5,065.39
Miscellaneous	2,000.00
Total	126,305.90

The North Carolina station is conducted jointly by the State department of agriculture and the college of agriculture. The extension work is also under the same supervision and is carried on in

close cooperation with station workers. The station is addressing itself to leading problems in the State, resting its practical suggestions on a sound basis of experiment, in which the branch stations are a feature.

NORTH DAKOTA.

North Dakota Agricultural Experiment Station, *Agricultural College*.

T. P. COOPER, B. S. A., *Director*.

The work of the North Dakota station was somewhat disturbed during the year as a result of conditions that affected the organization of the station. J. H. Worst retired from the office of president of the institution and was succeeded by E. F. Ladd. L. R. Waldron was appointed in charge of crop-breeding work, and D. C. Milbrath, assistant botanist, left the staff. The resources of the station were the same as for the previous year. From the State the station received \$25,000 for general work, \$3,500 for creamery apparatus and equipment, \$3,000 for maintenance of the serum institute, \$25,000 for the maintenance of five substations, \$5,000 for special live-stock work, and \$12,000 for demonstration farms. The research work of the station is probably on a better basis than ever before, and the plan of organization is satisfactory and effective.

Adams fund projects.—Work on the milling quality of wheat was carried forward with good results. Special attention was given to the capacity of wheat milling products for moisture as compared with gelatin, starch, and various other substances. It appears that well-developed wheat kernels hold more moisture than poor kernels. All flours of whatever process contain 1 to $1\frac{1}{2}$ per cent less gaseous moisture than the wheat from which they were made. The starch of high-grade flour contains more water than that of low-grade flour and the same is true for the flour as a whole. It is also found that damaged and sprouted wheat reached the maximum of its moisture content more quickly, but that the total water content was less than with good wheat.

Further study of the organic matter of soil indicated that there is a great difference in reaction of wheat soils and virgin soils. Long-continued cultivation appears to deprive the surface soil of its calcium carbonate, thus bringing about an apparent acid condition. In cases where acidity has not become evident the fact is explained to be due to soluble substances of alkaline reaction produced in the soil by natural weathering of soil particles. This study of lime requirement of soils has been found to be of quite a little interest in connection with the further investigation of organic matter.

Factors which influence the action of microorganisms on the liberation and accumulation of plant food in the soil received active

attention and interesting results were obtained in the course of this work. Rather striking success was had in the preparation of synthetic media for the growth of soil bacteria. Media of different energy potentials were devised as a means of grouping bacteria. All the media were prepared from compounds of known composition and structure. It was found that silica jelly is the best agglutinant, giving uniformly good results. Any acid stronger than carbonic acid will precipitate the silica jelly. In the nutrient solutions which are being used, pure chemical compounds are employed containing only one source of nitrogen and only one source of carbon. Results indicate that microorganisms show pronounced selective tendencies toward particular forms of nitrogen and carbon. It is also found that the competition of microorganisms for plant-food constituents is at its maximum when there is an excess of available energy material at their disposal and approaches a minimum as the available energy material falls below the energy nutrient ratio. A point may be reached where the liberation of plant-food constituents is retarded if the proportion of available energy material to nutrients falls too low.

In continuing the study of flax wilt, attention was given to the enzymic action of resistant and nonresistant strains of flax. Both catalase and oxidase appear to be present in resistant and nonresistant varieties. The oxidase content of nonresistant flax is about 80 per cent as strong as in resistant flax. This is the only positive difference thus far found. All other enzymes were present in equal quantity in both resistant and nonresistant strains of flax. There appears, therefore, to be little hope of finding a positive chemical difference between resistant and nonresistant flax and it is proposed to abandon this line of investigation.

A study of swamp fever brought to light many interesting conditions. The disease appeared only to a slight extent during the year. The relation of bot flies to swamp fever was carefully studied. Bot-fly larvae were crushed and an extract was prepared by maceration in salt solution. After this the extract was filtered and injected subcutaneously and intravenously. The extract proved extremely toxic, killing some horses within 40 minutes. The blood from dead horses reproduced the disease in healthy horses, causing an elevation of temperature and symptoms of swamp fever within 12 to 18 days. The cause of swamp fever still remains doubtful and it is believed that the symptoms produced by extract of bot-fly larvae are not strictly the same as those of swamp fever.

The investigation of hog-cholera serum was carried forward systematically, with particular reference to the influence of certain immunity factors upon the virus. Certain classes of virus for use in producing hyperimmunization were passed through pigs possess-

ing varying degrees of resistance. A serum produced from each group of virus was separately tested and graded. Incidentally it was learned that serum kept in a refrigerator for six years maintained its full potency and even when maintained at a room temperature or body temperature for 212 days the serum was still completely potent. It appears, therefore, that a good quality of serum is not destroyed by cold, freezing, or putrefaction.

The new project on the hybridization of subspecies of wheat with reference to the modes of inheritance of susceptibility to stem rust was actively begun. This work is concerned chiefly with a study of rust resistance of wheat from a genetic viewpoint. About 30 rows of wheat with varying degrees of immunity or susceptibility were under observation. More than 700 crosses have been made to obtain the material for further study. It has been found that eincorns, Black Persian wheat, and certain other varieties are practically immune to rust.

Work with Hatch and other funds.—The station carried on a large variety of experiments in agronomy and animal husbandry. This work included a study of forage crops for pigs, sheep feeding, pasture experiments with native prairie grasses, grazing corn, Holstein breeding, and general fertility and rotation experiments. In a comparison of various legumes and other crops as pasture for pigs, alfalfa proved to be the best, followed by sweet clover. Sweet clover seeds itself and continues in good condition for three years. It may also be pastured in both spring and fall. In a sheep-feeding experiment at Williston it was found that pasturing off corn by sheep is a good practice. In making alfalfa silage it was found incidentally that the beards of wild barley grass are softened in the silo, therefore becoming harmless. At Mandan the experiments on native prairie grasses are so arranged as to allot 3, 5, 7, and 10 acres per steer on different plats. Studies are also in progress of methods for improving native ranges. The Holstein breeding experiment is essentially a system of grading up and involves the use of 249 cows. The yield of butter fat appears to be gradually increasing. In fertility work carried on at the station it was found to be necessary to tile drain the plats. Most of the varieties of cereals have been dropped out and attention is now given to only a few of the best varieites. Rotation experiments have been carried on since 1892. One plat has been in wheat continuously. The yield on this plat is low in unfavorable years but is not diminishing rapidly. It appears that the rapid decrease in flax culture in North Dakota is primarily due to difficulties in controlling the weeds in the flax fields.

Some interesting results were obtained in the study of avian tuberculosis. It was found that mammalian tubercle bacillus produced extreme emaciation in fowls and English sparrows. The sparrows,

although becoming excessively emaciated, showed no lesions but still carried pathogenic tubercle bacilli, being therefore considered as dangerous carriers of the disease. The same condition was found to be true for chickens.

The chemical division continued its investigation of paints and oils with particular reference to reducers for white leads, substitutes for turpentine, and driers to be added to paint oil. The division also conducted a systematic study of the relation of weeds to fertility of the soil with particular reference to the amount of fertility removed by the growth of weeds. A large number of analyses were made in the study of sugar beets and in investigating the chemical and physical constants for wheat and mill products.

The horticultural division carried on experiments in tomato breeding and cultural and variety tests with sweet corn, onions, radishes, beets, strawberries and other small fruits, and also a study of the economics of the general farm garden. Some of the most promising strains of tomatoes were raised in the greenhouse and selections were made for a second crop. Many of these strains have been discarded, but 200 are still under observation. Preliminary results indicate that certain varieties are especially suitable for greenhouse culture. In a comparative test of fall versus spring seeding for radishes, onions, beets, and other garden crops fall seeding gave 20 per cent better yields. Experiments with ornamentals are in progress at Mandan, and also at Fargo.

Considerable attention was given to breeding brome grass for pasture and hay. About 7,000 plants were maintained in the breeding plats. From these plants 100 were selected for detailed measurements at five-day intervals. Particular attention was given to the tendency of brome grass to split up into hay and pasture types. Careful records are kept to show whether individual plants were leafy or otherwise. In experiments to determine the hardiness of strains of Grimm alfalfa one very pure and striking strain has been obtained. A study will be made of the extent of natural cross-pollination in alfalfa.

The botanical division continued its work on wheat-sick soils, which has also been extended to flax-sick and corn-sick soils. This work includes fertilizer experiments with reference to the prevalence of disease in wheat, corn, and flax, a comparison of grain farming and live-stock farming as related to these diseases, spraying experiments, seed treatments, and other problems. Fungi belonging to five or more genera have been found in cereal seed. Rotation systems in connection with this work are considered as being primarily systems of soil sanitation. The seed laboratory which receives State funds for use in standardizing flax and wheat seed will hereafter be connected with the college and not with the station.

The zoological and entomological work included a study of rodent extermination and blood-sucking flies. Some of the work of rodent extermination was largely of demonstration nature, but investigations were begun to determine the distribution of prairie dogs in portions of the western part of the State. Data, accumulated during work in prairie-dog towns, indicated that the cost of eradicating prairie dogs, including labor, need not exceed 10 cents per acre. Large quantities of poisoned bait were used in this experiment. A beginning was made on a study of blood-sucking flies, particularly the bot fly and nose fly of horses.

The following publications were received from this station during the year: Bulletins 112, Fertility and Weeds; 113, Report of Progress in Sugar-beet Trials; 114, Chemical and Physical Constants for Wheat and Mill Products; 115, Sheep-feeding Trials at Williston Substation; Special Bulletins Food Department, Volume 3, Nos. 18-23; Special Bulletins Food Department, Volume 4, Nos. 1-4; Circulars 7, Flax for Seed and Oil; Harvesting and Storing the Crop for Seed and Oil Purposes; 8, Home-grown Seed Corn; 9, Marketing the 1915 Hog Crop; 10, The North Dakota Farmstead, Its Arrangement and Adornment; 11, Poultry Management—Care of Breeding Stock and Chicks; 12, The Seed Field; 13, Trials with Alfalfa as a Hog Feed—Some Pasture Crops for Hogs; the Annual Report for 1915, parts 1 and 2; the Annual Reports of the Dickinson Substation for 1911, 1912, and 1913; and the Annual Report of the Williston Substations for 1913.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation, including balance from previous year -----	16,511.26
Farm products-----	32,307.87
Miscellaneous -----	29,886.24
Total -----	108,705.37

Much serious attention has been given to the matter of organization at the North Dakota station, and efforts in this direction have apparently yielded very satisfactory results. The research work of the station as a whole is progressing actively, and the prospects for the station are good.

OHIO.

Ohio Agricultural Experiment Station, Wooster.

C. E. THORNE, M. S. A., *Director.*

Few important changes occurred in the personnel of the staff of the Ohio station. Ten or more appointments to subordinate positions were made and four resignations were reported. It was decided

during the year to limit the regular series of bulletins to technical reports of investigation and to publish for general distribution a monthly bulletin containing summaries of the more technical bulletins and papers of a general nature heretofore published as circulars. The State appropriation for the year was approximately the same as for the previous year. A new building for the animal-husbandry department is under construction, and will be devoted chiefly to meat and wool investigations and to the study of animal parasites. According to a State law recently enacted the revenues from the sale of products, with the exception of the Hatch and Adams sales fund, are required to be turned in to the State treasury. L. L. Rummell was appointed editor.

Adams fund projects.—The projects on the phosphorus supply of Ohio soils and on the effect of excess or deficiency of phosphorus and other essential plant-food elements on the character of plants were actively continued. Phosphorus compounds in basic and acid soils were studied, especially in a series of pot experiments. Soils from cultivated and virgin areas have been collected. The results thus far obtained indicate that the active soil phosphorus, as shown by solubility in weak acid, varies in different types of soil. In some cases it follows the total phosphorus content of the soil but the soluble phosphorus appears to be influenced by the basicity and organic content of the soil. The total phosphorus content of Ohio soils thus far examined ranges from 180 to 3,400 parts per million. The relation between the phosphorus and nitrogen supply of the soil and the phosphorus content of wheat is such that an increase in the phosphorus supply of the soil appears to cause an increased amount of phosphorus in the wheat, closely associated with the yield.

In a study of the effect of excess or deficiency in the soil of essential plant foods upon crops certain crops were grown at five of the county farms on different soils and with different fertilizer treatments. In this work particular attention was given to the wheat plant, and in all instances the influence of varying quantities of nitrogen and phosphorus on yield and quality was studied.

The investigation of the sulphur requirements of crops was further pursued with interesting results. It appears that soils well supplied with organic matter contained more sulphur than soils which held a smaller amount of organic residues. Like phosphorus, sulphur is found in larger amounts near the surface than in the lower layers of the soil. Treatment with fertilizing materials containing sulphates increased the sulphur content of the soil. The cultivation of a silt-loam soil for 16 years without the addition of fertilizers has somewhat decreased the total sulphur supply. A study of the water extract of soils indicated that there is a consider-

able accumulation of sulphates in silt-loam soil deficient in organic matter.

The study of the physiology of nitrification was actively pursued, with particular reference to the improvement of chemical methods for determining nitrogen and the physiological and morphological study of nitrifying organisms. An elaborate review of the literature of this subject has been made. Several important improvements have been made in methods of determining nitric nitrogen in soils. The physiological and morphological studies were confined largely to the isolation and cultivation of a nitrite-forming organism. Unexpected difficulties were met in this work, and much time had to be expended in improving the accuracy and design of incubators. Pure cultures were finally obtained. The organism resembles that previously reported from South America. Morphological studies were also made on a nitrate-forming organism. Attention will be devoted during the coming year to the fundamental physiology of nitrifying organisms.

The cytology of *Azotobacter chroococcum* received less attention than the problem of nitrification, but considerable progress was nevertheless made. Efforts were directed largely to the determination of the influence of different forms of nitrogen on the morphology of the organism. A special study is being made to determine whether nitrogen fixation is a physiological or a pathological function.

Continued progress was made in the study of the rôle of phosphorus and other mineral elements in animal nutrition. The investigation of mineral metabolism in milch cows was completed and the data have been largely tabulated. A bulletin was also published on the iodin content of foods. It appears that liberal milk production on common winter rations, fed in quantities sufficient to maintain live weight and to cause regular storage of nitrogen and sulphur, brings about losses of calcium, magnesium, and phosphorus from the skeleton of the cow. These losses were shown to occur in spite of liberal supplies of the nutrients in the feed. A further study will be made of the limited response of cows to an increase in the intake of these elements. An excess of inorganic acids over inorganic bases in a ration, due largely to the silicon of timothy hay, cause an acid reaction and an increase in the ammonia of the urine. In the study of iodin in food products analyses were made of a great variety of plant and animal substances. In the order of increasing abundance of iodin these products are grouped as follows: Nuts, spices, fruits, cereals, hays, forage crops, garden vegetables, root crops, leguminous seeds, and animal products. No evidence was obtained that the presence of iodin in foods which contain iodin is essential. In most cases iodin appears to be an incidental constituent. Among the

animal products the only ones which contained iodin in more than mere traces were hair and hoofs. Iodin was found in the cereals only in traces and without apparent relation to the methods of fertilization or treatment. The more important sources of iodin in the human diet appeared to be garden vegetables, and in the diet of live stock, hay, silage, and forage crops. During the course of the study of mineral nutrition of animals much attention has been given to the determination of inorganic phosphorus in plant and animal substances. Some of these studies have been published in bulletin form.

In the study of methods of estimating metabolic nitrogen the specific effect of this element was investigated. Various rations, comparable with reference to digestible nutrients and other qualities, were compounded, an egg and blood albumin were used under the assumption that both are completely digestible. Different methods for determining the metabolic nitrogen were used to test their accuracy. On account of the delicacy of such tests it is thought possible that different methods may be required under different conditions, such as different animals and rations.

Decided progress was made in the projects on cereal breeding. Pure line breeding work with wheat, continued during the year, showed wide variations in many directions. Variations of practical importance, however, were not numerous. A large majority of the individual plants appear to occupy a position close to the average of the variety, while a few depart widely in both directions. In following the pure line method of selection decided differences in winter resistance, stiffness of straw, yield of grain, and bread-making qualities have been found in the progeny of individual heads selected from ordinary varieties of wheat.

Work with Hatch and other funds.—The department of animal husbandry carried on a large amount of experimental work with horses, sheep, cattle, hogs, and poultry. A feeding experiment was carried on with colts to determine the cost of raising on different rations. In beef cattle the cost of production up to different ages and the cost of maintaining beef-breeding herds are being studied. Several rations are also being compared for efficiency in beef production. A comparison is under way between close confinement in the stable and the use of pastures for beef cattle. Experiments with sheep were conducted chiefly at the main station and at Carpenter. This work consisted of a comparison of the value of forage crops and silage in sheep feeding, and a study of wool production. Some experiments were conducted to determine the influence of washing before shearing and of the time of shearing upon the quality of wool. Washed sheep produced 1.49 pounds less grease wool per head when shorn April 12 and 2.64 pounds less per head when shorn

June 1 than did unwashed sheep. It appears that in many cases an insufficient premium is paid for washed wool to cover the cost of washing and loss of weight in wool. Since washing sheep does not improve the quality of the wool fiber, the practice is apparently not to be recommended. Sheep shorn on April 12 produced more scoured wool than sheep shorn June 1. Several experiments were conducted in the management and handling of poultry. In a comparison of range and confinement for poultry the mortality was 23 per cent for the confined lot as compared with 15 per cent for the lot on range, and the average egg production of the hens on range was 15.4 per cent higher. In comparing a variety of feed and simple rations the egg production for the lot which received a ration of corn and meat scrap was 5 per cent lower than that of the lot which received corn, wheat, oats, bran, and meat scrap, and 20 per cent higher than that which received corn, bran, and meat scrap. An experiment was also conducted to determine the effect of various amounts of protein in rations. In three lots of fowls which received rations carrying approximately 10, 15, and 20 per cent of crude protein the mortality was 28, 24, and 33 per cent, respectively, and the largest number of eggs was produced by the lot which received 15 per cent protein.

The principal lines of work carried on by the agronomy department included variety tests with alfalfa, rotation experiments, fertilizer experiments, and improvement work. The value of clover in the maintenance of soil fertility is being studied in connection with the rotation system. Some attention was also given to a study of the effect of scarifying clover and alfalfa seed. The rotation experiments include 50 plats, of which 40 are devoted to rotations and 10 to continuous cropping. On one series of plats wheat yielded 27 bushels per acre after potatoes, 37 after soy beans, and 35 after oats, the only varying factor being the preceding crop in the rotation. Unfertilized wheat in a five-year rotation has averaged 42 per cent higher in yield than unfertilized wheat in continuous culture. Wheat has declined less in yield in the continuous-culture plats than has corn. The use of phosphorus alone increased the yield of wheat from 4 to 8 bushels per acre, while a complete fertilizer produced an increased yield of 8 to 16 bushels per acre. Deep plowing has shown an apparent gain of 0.43 bushel of corn over shallow plowing.

The work of the botanical department consisted largely of studies of plant diseases, weed and seed control, and experiments with tobacco. The tobacco experiments were conducted chiefly at Georgetown. Much attention was given to the diseases of cereals, forage and garden crops, and tobacco. About 2,000 identifications of weeds were made during the year, and numerous seed tests and examinations were performed. Quite striking success was had in the tobacco

work, especially with Havana crosses. Crosses of Cuban and Connecticut Seed Leaf tobacco are also under observation. Some attention was given to methods of disinfecting tobacco plant beds in the control of root-rot fungus and other diseases. Good success was had by both steam sterilization and drenching with formaldehyde. The advantages of steam sterilization over formaldehyde consist largely in its more certain effectiveness and a destruction of weed seed.

The chemical department studied the effect of various fertilizing materials on the availability and concentration of nitrogen, the loss of nitrogen from manure by drying, and the retention of nitrogen in liquid manure when treated with sulphur, acid phosphate, calcium carbonate, or floats. It was found that manure spread out and left for three months, from May to August, lost from 20 to 40 per cent of its nitrogen. Acid phosphate and sulphur were decidedly the most efficient agents for retaining the nitrogen of liquid manure. The losses from clover cut and left lying on the ground or worked into the soil were found to be about 64 per cent of carbon when left on the ground for 206 days, and 26 per cent when worked into the soil. Considerable attention was also given to the technology of milling and baking and to an investigation of the accumulation of salts in Ohio soils.

The horticultural work of the station involved a wide range of experiments with orchard and bush fruits and garden vegetables. An elaborate study of the varieties of apples in Ohio was published in bulletin form. Breeding experiments were continued to secure blight-resistant strains of apple trees. The comparison of cover crop and mulching systems, as originally made at the main station, was conducted on a wider scale in cooperation with farmers. It was found that mulching has in many ways the same effect as cultivation or the growing of a cover crop. The soil moisture content was highest and most nearly constant under mulch. Nitrification seemed also to be promoted by the use of mulch. Some experiments in the renovation of old orchards on depleted lands are under way, and similar work is in progress on peach orchards on Catawba Island. Breeding experiments with lettuce were conducted in the greenhouses.

The entomological department studied the relation of insects to the transmission of plant diseases, and collected data on the life history and means of combating a number of insect pests, including plant louse, codling moth, scale insects, onion maggot, nut weevils, cankerworm, granary insects, and household pests. In a study of the grape berry worm the life history of this pest was carefully worked out. It appears that the insect may be controlled by three sprayings—one just before blooming, a second when the grapes are

the size of peas, and the third from July 10 to 15. Arsenate of lead at the rate of 4 pounds in 50 gallons of Bordeaux mixture has given excellent results. It is recommended that the second spraying be applied just before the eggs are laid upon the grape berries. A careful study was also made of the life history of the clover-leaf tyer, with reference to the bearing of these data upon practical means of control. It appears that the present custom of harvesting and pasturing clover furnishes a fairly effective program of control.

The department of farm management is largely concerned with the management of district and county experiment farms. In addition to this work, statistical studies are made on rotations, types of farming, successful and unsuccessful farms, small farms, income from pasture lands as compared with cultivated lands, farm equipment, systems of farming as affected by markets and roads, and cost accounting.

The work of the forestry department was concerned chiefly with the propagation of forest trees, methods of reforestation, care of forest arboreums, forest management, wood utilization, commercial tree studies, and municipal forestry. Active cooperation has been secured from several cities in the establishment and maintenance of municipal forests and forest parks. Some experiments were also made in methods of controlling the damping-off fungi of coniferous seedlings.

The department of dairying continued its work of improving dairy herds by selection of sires and removal of inferior cows. Experiments were also conducted in comparing various calf-meal mixtures and in the study of dairy-farm management. Attention was given to the relative food values per acre of silage from various types of corn. In a study of the cost of raising dairy heifers it was found that the daily gain of Jerseys for the second year was 0.8 pound, while that of Holsteins was 1 pound, and the total net cost for the second year was \$36.01 and \$38.44, respectively. The average cost from birth to calving at the age of 26.5 months was \$91.39.

The soils department continued its work on the detailed soil survey of the State in cooperation with this department. The mechanical and mineralogical analyses of soil samples were made during the winter.

The following publications were received from this station during the year: Bulletins 285, Tobacco—Influence of Fertilizers on Composition and Quality—Experiments with Fertilizers and Manure on Tobacco Grown Continuously and in Rotation with Wheat and Clover; 286, County Experiment Farms in Ohio, Annual Reports for 1914; 287, Ohio Weather for 1914; 289, Raising Dairy Heifers—Cost, Feeding, and Care; 290, Varieties of Apples in Ohio; 291, Experi-

ments with Laying Hens—I, Range versus Confinement; II, Variety versus Simple Rations; III, Various Amounts of Protein in Rations; 292, Sulphur in Relation to Soils and Crops; 293, The Grape Berry Worm, *Polychrosis viteana*; 294, Wool Studies—Washing Before Shearing—Time of Shearing; 295, The Mineral Metabolism of the Milch Cow—First Paper; 297, The Clover-leaf Tyer (*Ancylis angulifasciana*); 298, Wheat Experiments; Technical Bulletins 6. The Metabolism of Organic and Inorganic Compounds of Phosphorus; 8, Studies on the Estimation of Inorganic Phosphorus in Plant and Animal Substances; Monthly Bulletin, volume 1, numbers 1-6; Circulars 154, Some Important Insect Pests of the Greenhouse; 155, County Experiment Farm Law; 156, How to Disinfect Tobacco Plant Beds from Root-rot Fungus (*Thielavia*); and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	282,543.00
Farm products	23,318.70
Miscellaneous	24,209.49
Total	360,071.19

The Ohio station continues to enjoy the cordial support of the farmers of the State. Through its scientific studies it is making large contributions to an understanding of many of the urgent problems of agriculture.

OKLAHOMA.

Oklahoma Agricultural Experiment Station, Stillwater.

W. L. CARLYLE, M. S., Director.

Progress was made at the Oklahoma station during the year both in the quality of its experimental work and in efficiency of administration. Several changes were made in the station staff, which was thereby considerably strengthened. F. M. Rolfs succeeded N. A. Booth as horticulturist. L. G. Herón resigned as assistant horticulturist. W. Macfarlane was appointed in charge of research work in soils. The station entomologist was relieved of the control work which had previously been part of his duties. Morrill Hall, which was injured by fire, was completely restored and made fireproof. The only new buildings erected during the year were a poultry house and a work office and implement shed for the horticultural department.

Adams fund projects.—The effect of cottonseed meal and other highly nitrogenous feeds on breeding stock was studied with hogs and poultry. Particular attention was given to cottonseed meal, tankage, and flaxseed meal. It was found that cottonseed meal could be fed to poultry, even in excessive amounts, without diminishing the hatchability of the eggs and vitality of the chicks. Further work will be done with reference to the effect of these feeds upon breeding swine, in which some histological investigations will be made. The study of artificial impregnation was confined largely to microscopic work on reproductive cells in fowls.

The vitality of hog-cholera virus received considerable attention. Comparative tests were made of the efficiency of virus received from several sources. In one case the virus remained virulent for 104 days. A pig inoculated with the same virus after it had been dried for 130 days proved resistant to virulent strains of the virus upon later testing. The project on immunity in vaccinated hogs was prosecuted actively. Vaccination with serum alone gave an immunity which persisted for 53 or 54 days. Other methods of producing immunity are under study, but the results are not yet ready for publication.

In continuing a study of the factors which affect setting of tomato fruit, the results threw some doubt on the previous announcement that the failure to set fruit was due to thrips. Spraying experiments were conducted for the control of thrips, but without satisfactory results. It now appears that the problem is largely a physiological one. A trial of different varieties of tomatoes, with reference to this problem has been begun. The study of the limits of grafting has been temporarily brought to a close on account of the loss of the original material from the old orchard in the fire in Morrill Hall. The effect of cultural operations and fertilizers in modifying the development of fruit buds continued to be the subject of active investigation. The appearance of *Bacterium pruni*, however, on the peach trees greatly interfered with the study of the project, and until the apple trees reach a larger size it may be desirable to abandon the investigation.

The study of inheritance in Black-hulled White Kafir was begun in 1915, and selections were made upon a basis of 25 sets of characters. This proved to be too large a number of characters for simultaneous study, and the number will be reduced to 8 or 10. In connection with this work preliminary experiments were begun to determine the limits of crossing. A beginning was also made on the project relating to the effect of lime and organic matter on an impervious subsoil. Preliminary work included a study of the root systems of Kafir and cotton on two types of soil and moisture content and soil temperature.

The entomological investigations of the station proceeded satisfactorily. It was found that the corn root-louse is more destructive to sorghum and broom corn than to maize, causing an annual loss of about 5 per cent. Some points in the life history remain to be worked out before control measures can be definitely begun. The investigation of the cowpea louse was practically completed. The winter form of this aphis has not been found in Oklahoma, and it is thought that the insect migrates annually from the South. The study of the biology and habits of the white ant was practically completed. The life history data which are still wanting are concerned largely with the period and date of hatching.

The comparative reproductive capacity of the Carniolan and Italian bees was carefully studied. Considerable improvement was made in a counting apparatus for determining the number of eggs produced by the queens under observation. The highest total egg production recorded for any one queen was 250,000 eggs at the age of 18 months. Considerable difficulty was experienced in getting pure strains, particularly of Italian bees. A strain of Caucasian bees will be secured for study in comparison with the other two breeds. Considerable progress was made in perfecting technical methods for carrying forward the project on the artificial fertilization of queen bees. Additional data were also collected on the life history of stick-tight flea, chicken flea, and red mite of poultry. The investigation of the fish moth was begun, and considerable information was recorded regarding its life history.

Some interesting results were obtained in the study of the chemistry of the grain sorghums. Particular attention was given to the starches of these sorghums. It was found that the seeds of grain sorghums contain starch in amounts varying from 55 to 64 per cent, feterita, milo maize, and Kafir containing the highest percentage of starch. These starches seem to be especially suitable as raw materials for the manufacture of high-grade starch by the commercial processes. They show a definite shape when examined microscopically, and the grains are similar to those of cornstarch but somewhat larger in size. Attention was also given to the fatty acids and the physical constants have been determined for fats extracted from Kafir, milo, and feterita. Ash determinations are being made in connection with these studies. The study of the composition and properties of silage from grain sorghums was concerned largely with a determination of temperatures in the silage and the character of the acids formed during fermentation. Acetic, formic, lactic, and butyric acids have been identified. Some attention was also given to the corrosive action of silage on the construction materials. A decided corrosion of iron was noted.

The project on the effect of various feeds upon the quality of pork is conducted cooperatively by the chemist and animal husbandman. The animals are slaughtered and curing tests made at a packing house at Oklahoma City. Three lots of pigs were fed peanuts, cottonseed meal, and grain sorghums, respectively, after which they were slaughtered and the meats cured for chemical analyses. Cooking tests were also made on these meats. Cottonseed meal appeared to give a hard fat with a high melting point, while peanuts produced a very soft fat.

Further progress was made in the sheep-breeding project with reference to the establishment of a breed of sheep especially suited for winter lambing. About 90 ewes are now included in this experiment and attention is being given particularly to size, weight, conformation, horns, color, folding of skin, fleece characters, and time of breeding.

Work with Hatch and other funds.—All of the work of the station has been placed on a project basis. The chemical department conducted much analytical work for other departments and began a study of the relative value of different grades of cottonseed meal. Some difficulty was experienced in the determination of crude fiber and this matter will receive further attention. The relation of protein to crude fiber is under study. The chemical department also made a study of the poisoning of live stock by plants of the sorghum group.

The work of the horticultural department included cultural, pruning, and breeding experiments with tomatoes, spraying for the control of apple and peach diseases, variety testing with grapes, and a study of the resistance of beans to disease. Particular attention was given to the use of lime-sulphur and Bordeaux mixture in the control of a *Phyllosticta* disease of apple trees. Similar spraying experiments were conducted with peaches. Nearly all varieties of beans seemed to be affected with *Bacterium phaseoli*. The treatment of seed beans by dry heat and holding them in storage for a period of three or four years seemed to be a satisfactory method for controlling this disease.

The general work of the agronomy department involved crop rotations, fertility studies, and a comparison of continuous culture versus rotations, including the use of leguminous crops, small grains, and cotton. Some plant-breeding work was done on cotton, wheat, oats, grain sorghums, and peanuts. Cultural experiments with field crops are also in progress. Some attention is being given to improvement of pastures, a study of hay crops, and methods of seeding and time of planting in relation to hay production.

The dairy department made a study of ice-cream production and of market cream. Particular attention was given in the ice-cream

experiments to the factors which determine overrun and keeping quality. The veterinary department performed the bacteriological work which was needed in carrying on these studies.

The general entomological work of the year involved a study of the locust borer, false chinch bug, alfalfa webworm, bee raising, and honey plants. The life history of the alfalfa webworm was quite carefully determined.

The poultry work of the station during the year included a comparative test of the feeding value of cottonseed meal, peanut meal, and beef scrap. Animal proteins gave the largest egg production, but the highest hatchability was obtained by the use of cottonseed meal. The experiment will be repeated during the coming year. A preliminary study was begun to determine the cause of the death of incubator chicks. This work will be followed by a study of phosphorus nutrition and its bearing on the vigor of young chicks.

The following publications were received from this station during the year: Bulletins 106, Poultry, I and II; 107, Using the Babcock Test; 108, The Production of First-grade Cream; 109, The Alfalfa Webworm; 110, The Starches of the Grain Sorghums; Circulars 36, Silage Feeding; 37, The Comparative Values of Cottonseed, Cottonseed Meal, and Corn, as Shown by Chemical Analyses; 38, The Poisoning of Live Stock While Feeding on Plants of the Sorghum Group; 39, Oklahoma Insect Calendar; and 40, Cotton Anthraenose.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	5,891.46
Farm products, including balance from previous year	6,724.19
Total	42,615.65

Several factors have conspired to give the Oklahoma station a better prospect than it has enjoyed for several years. The work of this station is all on a project basis. The quality of the work has improved and the esprit de corps of the staff is good.

OREGON.

Oregon Agricultural Experiment Station, Corvallis.

A. B. CORDLEY, M. S., Director.

The work of the Oregon station was somewhat handicapped during the year by the lack of State funds, owing to failure of several of its regular appropriations. The branch stations received the bene-

fit of the continuing appropriation which provides \$5,000 for the southern Oregon branch station, \$3,000 for the substation at Astoria, \$5,000 for the Hood River substation, \$2,500 for the Moro substation, \$3,000 for the Hermiston substation, \$7,500 for the Union substation, and \$4,000 for the Harney substation. The State appropriation for the main station failed to pass at the last legislature and the only funds available were \$3,000 granted by the board of regents from the general funds available to the institution. Most of the members of the station staff continued to do both college and station work, but the station men do very little extension work except at irregular intervals.

The farmers' organizations of the State passed resolutions urging an adequate appropriation for station work. In general the funds are allotted to the different departments of the station in accordance with the apparent importance of the different lines of work to the agriculture of the State. The sales funds are used exclusively for station purposes and for the departments in which the funds arise. A hog barn, costing about \$4,500, was completed and will provide better facilities for experimental work in feeding. H. P. Barss was appointed botanist and plant pathologist to succeed H. S. Jackson, who resigned.

Adams fund projects.—The study of apple pollination was continued with particular reference to the cause of sterility. The biology and morphology of the apple as a whole have been under careful investigation. It appears that most of the edible portion of the apple and pear is of the same nature as the tissue composing the stem. A complete study is being made of the bud from the time it begins to assume form up to the full development of the fruit. A thorough microscopic examination was also made of the fibrovascular system of the apple. These studies are considered as of fundamental importance in determining the conditions which affect pollination and sterility.

Irrigation of apples and pears was further studied particularly with regard to the effect of various amounts of irrigation water upon such external characters of trees as growth and color. Careful attention was also given to the structure of the tissues under different amounts of irrigation. The work was largely confined during the year to potted dwarf pear trees in order to have all conditions under control. During the year the dwarf orchard pear trees used in the experiment were transferred to 16-inch wooden tubs and arranged in 3 lots of 16 each.

A study of pruning as a factor in bud formation was continued on about 3,000 apple trees. An orchard of dwarf 5-year-old trees has proved well adapted to this investigation. Summer pruning was found to exert no influence on the development of the axillary buds

except those immediately adjacent to the cut. Summer pruning, however, reduces the number of axillary buds. A large mass of data has been collected on the angle and diameter of shoots produced in different systems of pruning. A thorough statistical study of apple fruit spurs is under way in connection with this project.

The study of apple-tree anthracnose has resulted in working out the life history and pathogenicity of *Neofabrea malicorticis*. A final set of experiments on this project involved artificial inoculations and cross inoculations on pear and apple showing the disease to be transmissible from one to the other kind of tree.

In the study of gummosis of the cherry attention is being given to the pathogenicity of bacteria found in connection with the disease. The work as related to the cherry has been concluded and the project now involves a study of other stone fruits. About 150 trees of each of the principal varieties of stone fruits are devoted to this work. All of the stone fruits are susceptible, while the sour cherry is most resistant. An organism identified as *Pseudomonas cerasus* is connected with the trouble and is being studied with reference to possible biological strains. Control measures are also being investigated.

The investigation of lupulin and other active principles in hops was practically completed. The results indicate that in the process of sulphuring to bleach hops the resin is not affected, that sulphur dioxid does not combine with the essential oil of the hop, that the unsulphured hop contains sulphur in the sulphate form, but none which is volatile by steam distillation, and that the amount of sulphur in the unsulphured hop is practically constant. The resins were not affected by storage for two years at a temperature of 40° F., but at air temperatures the resins were broken down, about 20 per cent of the soft resin being transformed into hard, worthless resin.

A further study of the incubation of hen's eggs indicated that moisture in the incubator was a very important factor. The records show that the percentage of chicks hatched vary as the moisture conditions vary, and also that the chemical composition of the chicks at the time of hatching is affected by the same factor. In chicks from a dry incubator the yolk sac protruded and had not been properly absorbed. The percentage of chicks hatched was slightly in favor of the moist incubator even as compared with the hen.

The chemical investigation of spray materials was largely confined to arsenates. A lead hydrogen arsenate was prepared in a pure form. All attempts to prepare neutral lead arsenate failed and evidence was obtained that this compound does not occur in commercial lead arsenate. A basic arsenate which is considered as the principal constituent of the neutral commercial arsenate of lead was also prepared. Moreover, an analytical method for determining the amount of lead hydrogen arsenate in mixtures of this compound with the basic lead

arsenate was developed. Spraying experiments with these compounds showed that lead hydrogen arsenate has much better killing power than basic lead arsenate.

The activities of soil bacteria were studied by adding soil infusions to various proteins in an attempt to learn the rate of ammonification. In this work blood fibrin, albumin, and peptone were used. In further experiments pure cultures of *Bacillus subtilis*, *B. vulgaris*, and *B. mycoides* were used. *B. subtilis* produces the greatest amount of ammonia from all of the proteins used. Nearly all of the ammonia was found to come from mono and diamino acids.

The investigation of bark beetles infesting the Douglas fir was continued actively. The work involves a study of forestry and lumbering methods in relation to the problem of insect injury. In a list of insect species concerned it was found that 22 species of Scolytidae attack the Douglas fir. Quite complete data were secured on the distribution of several of these species and life history studies are being gradually completed.

A study of the comparative toxic values of insecticides was continued largely with arsenates of lead, both acid and basic, as well as the calcium arsenates. The work was conducted in the laboratory with caterpillars of *Malacosoma pluvialis*. It appears that acid arsenate is more actively poisonous. The use of lampblack and fuller's earth as absorbers of arsenic gave promise in preventing burning. When 0.75 gram of arsenious oxid was mixed with 2 grams of fuller's earth and shaken in 100 cubic centimeters of water, the mixture was highly toxic to caterpillars and caused no serious burning.

Work with Hatch and other funds.—The horticultural department carried on breeding experiments with strawberries, in which 200 new seedlings were obtained for fuller study. About 800 seedlings of known parentage of cherries are under observation. A large mass of data on the interfertility and intersterility of sweet cherries has been accumulated. A large amount of work was also done in prune breeding, pruning loganberries, studies of nuts, particularly filberts and walnuts, an investigation of the relation of the depth of planting to the mortality of young trees, a study of stocks suitable for prunes, and an attempt to standardize prune varieties. Some attention was also given to the relation of temperature, humidity, and air circulation to evaporation of prunes.

The general chemical investigations included analyses of soils and fertilizers and miscellaneous routine determinations of feeding stuffs, mineral waters, insecticides, and fungicides, as well as numerous analyses in cooperation with other departments of the station. Practically all of the different brands of arsenate of lead, arsenite of zinc, and lime-sulphur solution have been analyzed. In fertilizer

work at Talent it was found that alfalfa was greatly stimulated in growth by the addition of sulphur. Complete analyses were obtained of alfalfa from 45 plats. In all cases the percentage of nitrogen varied with that of the sulphur. Sulphur gave equally good results in any form in which it was applied (gypsum, super-phosphate, and flowers of sulphur).

The animal-husbandry work involved experiments in feeding beef cattle, sheep management, and breeding experiments with pigs. A study is also in progress on the cost of pork production, including a comparison of various concentrates, such as buttermilk, tankage, etc. Buttermilk has been found slightly superior to tankage. From breeding experiments with hogs it appears that certain sows and boars transmit great efficiency of gains. A general study of the management of farm flocks of sheep is being conducted.

The poultry work of the station was largely concerned with breeding for egg production. Most of the heavy yielding hens have been found to lay a large number of eggs for four or five years. Two of these hens have already laid more than 1,000 eggs each. By repeated selection the egg yield has increased from an average of 100 eggs for the first year to an average of 200 eggs for the eighth year. The Oregons, a cross between White Leghorns and Barred Plymouth Rocks, yielded an average of 220 eggs in 1916. Evidence has been obtained that large size of eggs is hereditary.

The division of botany and plant pathology carried on a wide range of experiments, including a study of the diseases of potatoes, pomaceous fruits, small fruits, rusts, Sclerotinia of legumes, bacterial blight of the filbert, and other important diseases. The work in apple spraying is conducted at the Hood River branch station for the control of scab and mildew. In these experiments lime sulphur, atomic sulphur, Bordeaux mixture, sulphur dust, and iron sulphid were used with excellent results. The powdery scab of potatoes appeared during the year. It seems to occur only in moist, cool sections and is not yet serious in Oregon. It was shown that scabby potato seed does not always produce a scabby crop. Rhizoctonia was found to be increasing in seriousness and silver scurf occurred during the season. Investigations have been begun on the bacterial blight of the filbert, which appeared in 1915. In spraying for peach-leaf curl applications of Bordeaux and lime sulphur, made at the end of November, resulted in perfect control. A Sclerotinia wilt disease of legumes is also under study.

The dairy experiments during the year included a study of market milk, butter standardization, the keeping quality of butter, milk veins, and the feeding of cows. The milk experiments indicated that care and cleanliness in handling the utensils and in drawing the milk from the cow largely determined the cleanliness of the milk.

A method was devised whereby the butter maker may determine accurately the amount of coloring necessary to add to bring his butter to a certain shade. The test only requires about 10 minutes and the apparatus is inexpensive. A study of the development of milk veins and milk wells as an indication of the milk-producing power of cows indicated that the interior veins may be exceptionally well developed and may carry more blood than the exterior veins, and that dairy cows can not safely be discarded simply because of possessing small exterior milk veins.

The agronomic work included a study of production of soiling and forage crops, rotation and fertility experiments, fertilizer tests, experiments with vetch and corn varieties, irrigation and drainage investigations in Willamette Valley and in eastern Oregon, and agricultural-survey work. Numerous variety tests were in progress with small grains and potatoes and breeding work with barley, involving selection in pure lines for yield and for a small percentage of hull. It was found necessary to dry seed corn in order to preserve it in a satisfactory condition in the climate of the Willamette Valley. In drying experiments in an electric oven corn was desiccated down to a 2 per cent moisture content without affecting its germinating power. Moreover, the germination of corn was found not to be affected by artificial drying at a temperature of 155° F. for 24 hours. Preliminary experiments were begun with white mustard as a spice. Results thus far obtained are favorable. The substations carry on numerous experiments at the suggestion and under the supervision of heads of departments. Much of the work at the substations is of an agronomic nature.

The bacteriological department carried on many routine bacteriological examinations of water, sputum, tissues, etc., and also made a large number of nitro cultures. It has been found that about 65 per cent of the cultures are effective in producing a gain of about 6 pounds of nitrogen per acre. The department is also cooperating with the departments of chemistry and agronomy and also with the North Dakota station in a study of avian tuberculosis.

The entomological work of the year involved a study of lime sulphur, a comparison of dust and liquid applications, and observations on peach borer, clover-seed insects, codling moth, and orchard plant lice. In an investigation of the relation of insects to fire blight at Medford and Talent various sticky preparations were used as repellents to prevent insects from crawling up the tree trunks. The results of this experiment are not yet tabulated.

The veterinary department carried on experiments relating to white diarrhea in chicks, sterility in cattle, infectious ophthalmia, and cooperated with the dairy division in the study of milk veins in cows. The agglutination test for use in the diagnosis of white diar-

rhea gave excellent results. The disease has been practically eliminated in a flock of 800 hens by applying the test and discarding the reacting fowls. An elaborate study has been begun on the causes of sterility in cattle. An outbreak of infectious ophthalmia in sheep was controlled by applying a 1 per cent solution of silver nitrate as an eye wash.

At the Hood River branch station experiments were conducted on the life history and control of the apple leaf hopper, fruit-tree leaf roller, woolly aphid, codling moth, and apple scab, and fertilizer and pruning experiments with apples were also continued. At the eastern Oregon dry-farming branch station the experimental work consisted largely of variety tests with cereals, tillage experiments, and a study of rotation and forage crops. At the southern Oregon branch station the chief experimental work was concerned with fertilizers for alfalfa and methods of preventing pear blight.

The following publications were received from this station during the year: Bulletins 127, Experiments in Swine Feeding; 128, The Arsenates of Lead; 129, The Pollination of the Pomaceous Fruits, II; 130, Pruning—Plant Physiology as Related to Pruning—The Study of Fruit Buds—Pruning Young Trees—Pruning the Bearing Apple and Pear Trees—Pruning the Bearing Prune Tree; 132, Economics of Apple Orcharding; 133, Points on the Selection, Adjustment, and Care of Farm Machines; 136, Vegetable Tests on Sandy Soil at the Umatilla Experiment Farm; Reports of the Hood River Branch Station for 1913-14 and 1914-15; and Report of the Umatilla Branch Station for 1913-14.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation, including balance from previous year for substations	50,558.02
Farm products, including balance from previous year	24,109.06
Total	104,667.08

The Oregon station is making satisfactory progress in all respects. The members of the staff show a striking loyalty to the institution and maintain cordial relations with one another.

PENNSYLVANIA.

The Pennsylvania State College Agricultural Experiment Station, *State College*.

R. L. WATTS, B. Agr., M. S., *Director*.

The work of the Pennsylvania station was carried forward without essential change of policy or personnel. No specific appropria-

tion is received by the experiment station for experimental work, except for the Institute of Animal Nutrition. The State funds used by the station are taken from the allotment made by the college to the teaching departments. These funds, in addition to the fund accruing from sales of products, are used to supplement the Federal funds. No new buildings were constructed during the year. A number of appointments and resignations occurred among the assistants in different departments. Work was begun on an experiment to determine the fertilizer needs of the De Kalb soils. The station also planned an extensive field test of different carriers of phosphorus.

Adams fund projects.—The investigation of the effect of different fertilizer treatments in a four-year rotation of long standing was continued. The fertilizers are applied every two years to corn and wheat. Samples are taken from the plats from about 80 borings on each plat and analyses are made of both surface and subsoil. Considerable trouble has been experienced in the proper interpretation of results, by reason of the original variation in the composition of the soil plats. The effect of different green manures on the lime requirement of soils taken from the rotation plats is being studied in pots. The experiment also involves the determination of the effect of various fertilizing materials on lime requirement. The lime requirement of the different plats showed a range varying from 0 to 3,200 pounds per acre. Limestone particles having a diameter of more than one-sixtieth inch caused little increase in the crop yields, while marked results were obtained from applying lime ground to a fineness of one one-hundredth inch or less (Pl. VI). Magnesium lime seemed to be slightly more effective than pure calcium limestone. A study of the rate of ammonification and nitrification in the soils of the rotation plats is also under way.

The factors which affect yield and quality of apples were further investigated on 6 types of soil involving 1,540 apple trees of 10 varieties. In general, the mulch treatment was most efficient in improving the yield, growth, and size of fruit in orchards under 20 years of age, while the sod treatment gave the lowest results. Fully matured orchards were most benefited by tillage treatment. As a rule cover crops did not show any great benefit. In 10 comparisons extending over 5 to 8 years each the gains from the use of manure and artificial fertilizers averaged 87.4 bushels per acre with tillage, and 75.6 bushels without tillage. The work includes the study of the same factors in the case of peach, and involves observations in eight apple orchards throughout the State. Special attention will be given to marked differences in effectiveness shown by applications of nitrogen, potash, and phosphoric acid in different locations.

Considerable progress was made in the project on the bacterial flora of some of the general fertilizer plats. The soils examined for this purpose came from plats receiving various treatments, as well as from untreated plats. The highest nitrification was found on the plat which received lime and manure. Little correlation was noted between nitrification and kind of crop. Nitrogen fixation, however, showed a parallelism with the yield of the crop.

Encouraging progress was made in nearly all of the projects in the Institute of Animal Nutrition. The study of the influence of condition upon the metabolism of cattle was completed, but the results have not yet been calculated. Progress was also made in the study of the partition of nitrogen in the urine of cows. Attention was devoted chiefly to the metabolism of cows, with reference to the relative utilization of energy in milk production and in fattening. The purpose of this work is to determine the total energy of feed consumed by cows, the losses of energy in the excreta, the expenditure of energy consequent upon the consumption of feed, and the net energy of the feed. Furthermore an attempt is being made to determine the distribution of this net energy between milk secretion and growth. This work is carried on in a respiration calorimeter. Incidental observations were made on the effect of varying amounts of the same combination of feeding stuffs in increasing milk production and body weight.

Work with Hatch and other funds.—A wide variety of experiments was conducted by the department of agronomy, including rotation tests, fertilizer experiments, cooperative work with corn and soy beans, variety tests with corn, oats, wheat, and potatoes, experiments with lime in various forms, and tests of the effects of deep and shallow plowing. In field experiments with lime no difference in effect was observed between burnt lime and ground limestone in equivalent amounts. In pasture experiments applications of manure, phosphoric acid, and nitrate of soda materially increased the growth of grasses. A large amount of crop-improvement work was carried on, especially in the selection of wheat, oats, and potatoes. Calcium cyanamid proved not to be as efficient a carrier of nitrogen as nitrate of soda. Practically no difference in the yields of crops was noted on land plowed 7.5 inches deep as compared with land plowed 12 or 13 inches deep, but fall plowing gave better results than spring plowing, either shallow or deep. A study of soil aldehydes indicated that these bodies do not remain long in the soil and are soon neutralized by lime or acid phosphate. In experiments with corn it was found that the seed from ears which germinated quickly gave a better germination in the field, and that better results were obtained from keeping seed at a living-room temperature during winter than with-

out artificial heat. Continued inbreeding greatly reduced the size of stalks and yield.

The animal-husbandry department conducted steer-feeding experiments with silage and several other rations, and also compared molasses with corn. With molasses at \$27 a ton and corn at 70 cents a bushel the molasses gave somewhat better results. A test was also made of the possibility of wintering cattle on cheap rations consisting largely of roughage. The cattle came through the winter in good condition and gained rapidly when put on grass. Further progress was made in the study of the cost of maintenance of the beef-breeding herd. A breeding experiment with sheep was also begun. Pig-feeding experiments included a comparison of green forage crops and dry-lot feeding, rations for fattening pigs, and maintenance rations for brood sows. It appears that the economic production of beef requires an inexpensive shelter, a reduction of the cost of labor, the use of larger amounts of roughage, and a comparatively long pasture season. The total annual cost of maintaining a Shorthorn cow was \$33.54, and \$34.11 for an Angus cow.

An experiment in keeping cows out-of-doors as compared with the use of a dairy barn was continued. A little more roughage was consumed by cows kept outside. Several experiments were also conducted in keeping cream in different kinds of cans, testing the effect on the acidity, bacterial growth, and keeping qualities. Silage as a sole roughage for cows was compared with silage and mixed hay, with results quite favorable to silage. Digestion trials are under way to determine whether lactation and gestation periods have any effect on the utilization of protein. Some tests were also made of different kinds of bedding material and of methods of handling cows. Considerable attention was given to a study of the bacteriology of silage. Observations were also made on methods of manufacturing butter in creameries and on the farm.

The botanical department studied a number of plant diseases and collected meteorological data regarding conditions which favor the development of the late blight of tomatoes and potatoes. Some work was also done on the life history of the blister rusts of forest trees. Breeding experiments with tobacco and phlox were continued. General observations were made on the life history and means of controlling collar blight and related forms of fire blight, and also of potato diseases.

The horticultural department conducted experiments with vegetables, particularly cabbage, tomatoes, asparagus, and rhubarb. With cabbage an attempt is being made to develop high-yielding strains. Considerable variation in this regard was noted, but difficulty was experienced in securing mature seed. Different strains of the same



FIG. 1.—PURE CALCIUM LIMESTONE (CaCO_3) IN DIFFERENT DEGREES OF FINENESS AS AFFECTING THE GROWTH OF CANADA FIELD PEAS, PENNSYLVANIA STATION.

Pot on left received equivalent amount of burned lime (CaO).

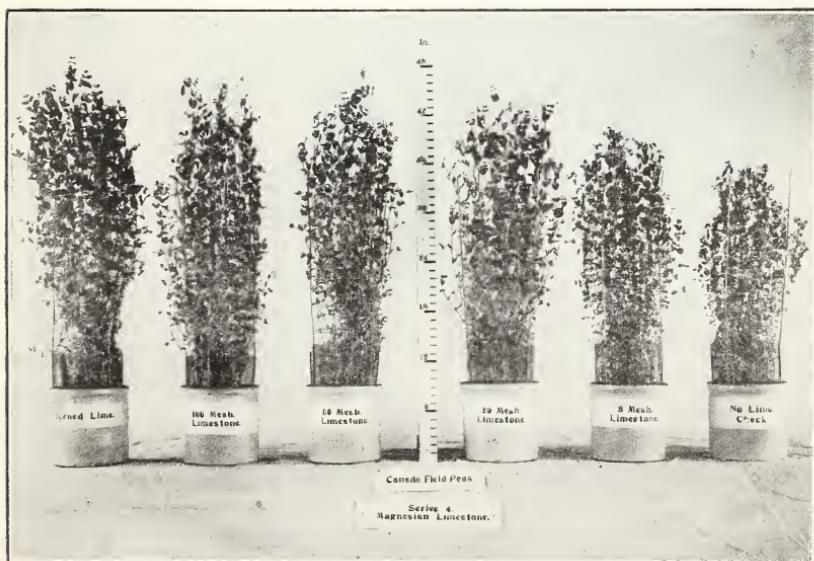


FIG. 2.—HIGH MAGNESIAN LIMESTONE (43.1 PER CENT MgCO_3 AND 53.2 PER CENT CaCO_3) IN DIFFERENT DEGREES OF FINENESS AS AFFECTING THE GROWTH OF CANADA FIELD PEAS, PENNSYLVANIA STATION.

Pot on left received equivalent amount of burned magnesian lime.

variety showed differences of 1,000 pounds in yield per acre. The experimental work with tomatoes is largely selection for improvement of quality. Some plants seem not to be able to transmit their good qualities. A statistical study of inheritance in tomatoes has been under way since 1912. Some rotation plats have been laid out, on which timothy and clover will be rotated with cabbage and tomatoes. In studying the fertilizer requirements of cabbage and tomatoes an attempt is being made to determine the relative importance of nitrogen, phosphoric acid, and potash for these crops. No considerable difference was noted in earliness or in productivity between large and small plants of early cabbage. A gain in yield occurred, however, when cabbage plants were set 24 by 18 inches apart, as compared with 28 by 18 inches.

The department of experimental agricultural chemistry continued its tobacco experiments in cooperation with this department. The work of the forestry department included an investigation of methods of planting seed of white and red pine and the use of wire screens and other protection for white-pine seed. A comparison of fall and spring seeding was in favor of fall seeding. By means of the use of wire screens it was shown that one of the causes of the failure of natural reproduction from broadcast sowing of white-pine seed is that the seed is eaten by squirrels, mice, and birds.

The following publications were received from this station during the year: Bulletins 135, A Study of the Manufacture of Dairy Butter; 136, Collar Blight and Related Forms of Fire Blight; 137, Experiments with Cabbage; 138, Raising Beef Cattle; 139, Experiments with Corn; 140, The Diseases of the Potato; and the Annual Reports for 1912 and 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
Fees	17,549.47
Farm products, including balance from previous year	35,204.41
 Total	 82,753.88

The Pennsylvania station has no State appropriation, and therefore has not been able to develop its work and improve the technical phases in certain lines.

The Pennsylvania State College Institute of Animal Nutrition, *State College*.

H. P. ARMSBY, Ph. D., LL. D., *Director*.

Most of the work of the Institute of Animal Nutrition is conducted under the partial support of Adams funds, and has been referred to above. The investigations of the institution center around the respiration calorimeter and connected apparatus which has gradually

been developed under the leadership of the present director. Such studies as retention of ash ingredients by cows in milk, the relative utilization of energy in milk production and in fattening, the partition of nitrogen in the urine of cows, and the influence of condition upon the metabolism of cattle are all made possible by the elaborate and extremely accurate apparatus, largely devised and constructed by the institution. The funds used in this work, aside from the Adams fund, are \$5,000 from the State and \$1,020 from the general college budget. The Bureau of Animal Industry of this department continued its cooperation with the institution and contributed \$3,500 to the work.

PORTO RICO.

Porto Rico Agricultural Experiment Station, *Mayaguez*.

D. W. MAY, M. Agr., *Agronomist in Charge*.

The work of the Porto Rico station continued along the same lines as in previous years. The loss of the use of the sales funds without compensating increase in appropriation made it impossible to take up certain new lines of work which are quite urgently demanded. A number of projects were completed and the results are being prepared for publication.

A large amount of attention was given to the improvement of Porto Rico soils. These soils have been found to be in good physical condition but deficient in plant food, particularly nitrogen. The expenditures of the farmers of the island for fertilizers are large, but even greater expenditures seem to be required. An effort is being made to learn of new and cheap resources of fertility. This work has involved the study of guano and phosphate deposits and also of cover crops. In Porto Rico there are numerous caves stored with bird guano. About 100 of these caves were surveyed and mapped with reference to data concerning the amount and quality of the guano. It is also proposed to study certain phosphate deposits on Mona Island near the coast of Porto Rico. Some attention was also given to the mother liquor from salt works for the purpose of determining whether the potash residue in the material may be profitably used for farm purposes.

An investigation of the value of cover crops was made particularly with regard to their use in orchards. Good results were obtained with cowpea, Jack bean, Mauritius bean, pigeon pea, and various wild leguminous plants. The Mauritius and Lyon bean, as well as a number of other varieties of velvet bean, were found well adapted for general use in open fields in preventing erosion and in aiding fertility. In the young coconut groves, before the shade becomes too dense, velvet beans, Jack beans, and cowpeas give satisfactory results as cover crops. Most legumes used for cover crops in Porto

Rico made their heaviest growth when planted in the spring or early summer.

For several years cooperative experiments have been carried on with the insular government with fiber plants. In this work a number of fiber plants suitable for cordage have been under study. It is proposed to carry on breeding experiments with sisal to develop a type containing a larger percentage of fiber. Decorticating machinery and other necessary mechanical devices will be secured for this work. The hat-weaving industry, which has been encouraged by the station, has grown rapidly, showing an exportation of hats to the value of \$500,000 during the fiscal year. A species of *Carludovica*, known as the jipi-japa palm, was introduced by the station, propagated on a large scale, and widely disseminated. This palm furnishes better materials for the manufacture of hats and at less labor than in the case of the one previously used for this purpose. Forest and other trees have been propagated at the station and distributed. These include mango, mahogany, eucalyptus, and leguminous trees.

The station herd of cattle has been considerably increased, and some improved animals are sold from time to time for the purpose of improving the quality of cattle in the island. A separator was installed and some experiments in butter making were conducted, as well as in the production of milk under modern methods.

Decided progress was made in the study of assimilation of iron by rice in various nutrient solutions. Some attention was also given to the extent to which rice roots show a selective absorption of mineral nutrients. A comparative study was made of the accuracy of various methods for determining iron in plant ashes. In the case of rice and pineapples it was found that iron, like silicon and calcium, is relatively immobile. Little evidence could be obtained of the transference of iron from one leaf to another of the same plant in cases where the plant was insufficiently supplied with iron. It is proposed during the coming year to study tobacco waste as fertilizer, the relative availability of different phosphatic fertilizers, and also to conduct a soil survey in connection with certain field experiments.

The horticultural division of the station devoted its energies chiefly to a study of the mango. This work has involved a comparison of numerous varieties. It appears that large seed are more desirable than small seed for planting. Successful propagation has been accomplished by grafting as well as by inarching. It was found possible greatly to increase the yield of coconuts by proper cultivation and the use of suitable fertilizers. In further work with vanilla a crop was obtained which brought \$2.50 per pound. Numerous cuttings of vanilla were distributed, and, since the shade trees available

for use in coffee plantations are also suitable as supports for vanilla, it is expected that the vanilla industry may soon assume commercial importance in the island.

Among the numerous coffee varieties under observation some gave a larger yield than the coffee now commonly grown. Seed from the most promising varieties is being distributed among the coffee planters. Cooperative experiments are in progress with coffee growers in testing fertilizers for this crop. It has been found that a light application of an equally available nitrogenous fertilizer at flowering time will induce a more complete crop of flowers than would otherwise appear.

The division of plant pathology devoted its efforts largely to a study of banana diseases. A better understanding has been reached of the nature of these diseases, and certain control methods have given favorable preliminary results in ameliorating the trouble. Considerable progress was made in the plant disease survey of the island, and this work is gradually resulting in a cryptogamic herbarium at the station.

The entomologist continued his investigation of the changa, or mole cricket, cattle ticks, and coffee insects. The study of the life history of the changa has been nearly completed. The investigation of cattle ticks is largely with reference to methods of control. The work with coffee insects will be continued during the coming year largely in cooperation with coffee growers in various districts.

The following publications were received from this station during the year: Bulletin 15 (Spanish edition), *La Apicultura Portorriquena*; 19, Cover Crops for Porto Rico; Circular 15 (Spanish edition), *Indicaciones Acerca de la Siembra de Cafe en Puerto Rico*; and the Annual Report for 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation-----	\$30,000.00
Farm products-----	1,313.69
Total -----	31,313.69

With the aid of an appropriation which becomes available for the coming year, the station plans to carry on some extension work. By this means it will be possible to bring more fully before the farmers of the island the important results of the station's investigations. It is also hoped that in time the appropriation for the station will be sufficient to permit the establishment of a branch station on the northern side of the island, where the fruit-raising industry is extensively developed.

RHODE ISLAND.

Rhode Island Agricultural Experiment Station, Kingston.

B. L. HARTWELL, Ph. D., Director.

Perhaps the most notable addition to the work of the Rhode Island station was the establishment and planting of a new series of plats to study certain market-garden problems in cooperation with representative market gardeners. It is expected that this work will occupy 100 plats. The first problem to be undertaken is a study of the feasibility of the substitution of green manures and commercial fertilizers for horse manure. An overhead irrigation system capable of delivering 80 gallons of water per minute from a near-by pond will be installed. Observations are also to be made on the effect of one crop upon the following crop. F. O. Fitts resigned as assistant in chemistry, otherwise the work and personnel of the staff continued without essential change.

Adams fund projects.—The study of problems of soil acidity was confined largely to a comparative test of the accuracy of chemical methods in detecting small variations in acidity. No conclusive results were reached. The effect of one crop upon the following crop continued to be the subject of active investigation. In 1913 buckwheat was grown without fertilizer following onions, rye, buckwheat, and redtop, yielding 21, 21, 13, and 10 bushels per acre, respectively, on the four plats. Seed from this crop has been grown for two years in pots under various fertilizer conditions and buckwheat was used in all pots in 1916. The results obtained during the year were similar to those previously reported. The yield of buckwheat was again highest after onions and rye and lowest after redtop. Alsike clover was tested as a hay crop following various other crops. The yield was highest following potatoes and decidedly lowest following red clover and alsike clover. When soy beans were planted with corn for silage purposes, the yield of corn was nearly as high as when corn was planted alone. When the rate of seeding, however, was greatly increased the yield of corn was diminished to such an extent that the soy beans did not make up for the difference.

The principal feature of the work on blackhead of turkeys was a study of methods of feeding to prevent the activation of the disease organisms in the intestinal tract. It has been shown that flagellate protozoa are concerned in the infective processes of the intestines and liver. An effort is being made to determine how the parasites gain access into the tissues of fowls. Histological studies have thrown some light on the avenue of the infection of the intestinal wall by the protozoan parasite.

Some progress was made on a study of the relation of the chemical composition of turnips to phosphorus deficiency of the soil. Attempts to find a reliable chemical method for determining the organic phosphorus in turnips were unsuccessful. The project relating to the influence of sodium salts upon the composition of plants was continued, chiefly with reference to the study of the relation of nitrogenous constituents of potatoes to seed quality as affected by fertilizers, culture, and storage. It appears that any retarding influence results in the accumulation of starch in the potato plant. A deficiency of available potash in the soil is usually accompanied by an accumulation of starch. Several other factors correlated in each case with retarded growth have been found to be associated with the accumulation of starch in the aerial portion of the plants. Much difficulty was experienced in the conduct of the project on the influence of physical soil factors upon carnations, but a fresh start was made with new materials.

The study of the physiological effect of nutrient elements upon plant growth by means of water cultures and pot experiments was continued. The data which have been accumulated during the course of this work are to be prepared for publication.

Inheritance studies with poultry have been under way for six years with particular reference to the inheritance of egg weight, plumage color, and body weight. This work has thrown some light upon the matter of inheritance of blue and buff colors. A sex-linked factor for inhibition of buff was discovered in the White Plymouth Rock. Strains of fowls were secured laying eggs one-fourth larger than the average and other strains laying eggs one-third smaller. Selection experiments on the inheritance of certain characters in rabbits were interfered with by the occurrence of a fatal disease among the experimental animals.

In the further study of the lime and magnesium requirements of plants an effort was made to render the experimental plats alkaline, since it was found that deductions from previous work were perhaps vitiated by the acid condition of the soil.

The investigation of the etiology and pathology of fowl cholera was concerned largely with the classification of cholera organisms, three groups being tentatively adopted. It appears that the agglutination test is a reliable method of distinguishing between true fowl cholera and other related diseases. Definite agglutination reaction was obtained with the bacteria of fowl cholera. Pigeons were rendered immune by means of dead cultures of the cholera organism. Much attention was given to the study of the relationship of the fowl-cholera organism to the paratyphoid organism which causes food poisoning.

The study of the bacterial infection of eggs was continued actively. Of 2,520 fresh eggs, 8.7 per cent showed a bacterial infection in the yolk. The bacteriological examination of 111 egg whites showed no infection, while the yolks of the same eggs were infected to the extent of 4.5 per cent. The percentage of infection for individual hens has varied in different years from 2.8 to 15 per cent. The percentage of infection for infertile and fertilized eggs appears to be about the same. It is believed that the most probable source of primary egg infection is the ovary of the fowl. No correlation was found to exist between percentage of infection, fecundity, hatchability, season of the year, and age of the fowl.

The study of the rôle of immunity inheritance, as a means of combating communicable diseases, was concerned largely with an investigation of the relations between the organism of white diarrhea, fowl typhoid, and paratyphoid. Experiments were also conducted on rabbits in which an attempt was made to immunize parents for the purpose of securing a passive immunity in the offspring. The organism used in these experiments is *Bacillus bronchisepticus*.

Work with Hatch and other funds.—As in previous years an extensive series of field experiments was conducted with various crops. This work included variety tests with potatoes, rye, corn, wheat, Sudan grass, and alfalfa. Rotation experiments which have been in progress for several years indicate that lime and chemicals may entirely replace manure in rotations in which one-half to two-thirds of the time of the whole rotation is occupied by hay crops. The attempt to produce satisfactory home-grown seed potatoes has not given complete success. Comparative tests of various forms of lime, floats, slag, and acid phosphate were continued. A comparison was also begun of various forms of potash salts on a series of plats in which the checks received no potash. A comparison of the relative value of sodium nitrate, ammonium sulphate, and organic nitrogen by means of pot experiments was continued.

When sown at the last cultivation of corn for a winter cover crop to be plowed under in the spring, alfalfa gave poor results, vetch was winterkilled, while sweet clover and mammoth clover proved to be quite satisfactory. In rotations of corn, potatoes, rye, and grass extending over a period of 20 years, vetch and clover have proved to be no better than rye as a cover crop. The importance of maintaining a supply of decomposing vegetable matter in the soil was demonstrated by a comparison of stable manure for a period of years with commercial fertilizers. As a top-dressing for grass the use of sulphate of ammonia, calcium cyanamide, and basic slag phosphate in the place of nitrate of soda and acid phosphate led to a decreased yield. With millet and rape, basic slag phosphate compared favorably as fertilizer with soluble phosphates. The yield of corn was found to be

dependent to some extent upon the amount of available phosphoric acid.

No deleterious effects have been observed from the use of lime products containing a high percentage of magnesia. The lime in basic slag phosphate was found to be readily available. Of the crops which were grown during the past two years to learn their lime requirements, sugar beets proved to have the highest requirement, followed by pumpkins, rape, Sudan grass, and carrots, while the yield of watermelons was depressed by the use of lime.

The new market-garden work is expected to become an important phase of the activities of the station. In addition to a study of the extent to which green manures and fertilizers may replace stable manure, attention will be given to the effect of one crop upon a succeeding crop and to the importance of irrigation in garden operations.

The work of fertilizer and feed inspection continued, as in previous years, to be a considerable feature of the station's activities.

The following publications were received from this station during the year: Bulletins 163, The Comparative Value of Different Sources of Phosphorus; 164, The Bacterial Infection of Fresh Eggs; Inspection Bulletins, September and October, 1914, and July and October, 1915, Analyses of Commercial Fertilizers; May, 1916, Analyses of Feeding Stuffs; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
Miscellaneous	2,370.18
Balance from the previous year	4,294.70
Total	36,664.88

The Rhode Island station is making important contributions in the special lines in which it is working. The establishment of the new line of study of market-garden problems should prove of immediate practical value in the development of this industry.

SOUTH CAROLINA.

South Carolina Agricultural Experiment Station, Clemson College.

J. N. HARPER, B. S., M. Agr., Director.

The work of the South Carolina station proceeded during the year without essential change of policy. All investigations have been placed on a project basis, involving nearly 100 active projects. The work at the Pee Dee and Coast stations has been organized on the same basis as that at the main station and some of the Hatch

and Adams projects are conducted partly at the branch stations. About 60 acres of land are used for experimental purposes at Clemson and 130 acres at the branch stations. A plan has been made for establishing long rotation experiments on a 20-acre plat. C. A. McLendon, field pathologist, and F. M. Rolfs resigned, the latter being succeeded by R. C. Faulwetter.

Adams fund projects.—The study of insect activity, as influenced by temperature and moisture, was carried forward satisfactorily. The laboratory apparatus for the control of temperature and moisture operated nicely. The work involves observations in both field and laboratory. Experiments with ladybirds indicated that they return to activity about the same date even when maintained at low temperatures. The controlling factor appears to be the relation between temperature and moisture. Some study was also made of the effect of temperature on cellular structure and reproduction of a number of species of insects. It appears that outbreaks of certain pests can be predicted when meteorological data are known for a given time and place.

Life-history studies on the slender wireworm were continued in cooperation with the Bureau of Entomology. Means for the control of this pest have been fairly well worked out, control seeming to depend on temperature-moisture relations. Drainage and irrigation will prevent outbreaks of the wireworm in some types of soil.

The further study of the effects of pollen from barren stalks of corn indicated that pollen from barren stalks will not always carry the character of barrenness. In one half-acre plat under observation during the year only four barren stalks were found although the staminate seed parent for five generations had been a barren stalk.

The relation between the soil and the length and quality of cotton staple was studied at the main station and at the substations. The fiber is graded and tested in the textile laboratory. Evidence has been obtained that soil moisture, especially at certain periods of growth, is the limiting factor. This preliminary conclusion, however, requires further confirmation.

The problems involved in the fecundation of *Rotundifolia* grapes received a large amount of attention. All male vines in the vineyard were removed in April, six weeks before the appearance of blossoms. Notwithstanding the fact, however, that there are no male vines nearer than 1 mile, the crop produced was as heavy as when male vines were allowed to grow within a few feet. No insects with the exception of lightning bugs were found on the grape flowers. The tentative conclusion was reached that some varieties of *Rotundifolia* grapes are self-fertile or are pollinated from plants bearing perfect flowers.

The project on cotton anthracnose is largely confined to the investigation of methods of control. As a result of this investigation the use of old seed and treatment of seed with hot water and sulphuric acid are recommended. The fungus organism has been found not to retain its vitality in the seed for more than two years. Experiments in spraying with Bordeaux mixture are also in progress. The hot-water treatment of seed for anthracnose proved very effective, not more than 1 per cent of bolls being diseased in any of the treated fields. Work on the causes of shedding of cotton bolls was conducted at the main station and at the Pee Dee branch station. In this study soil-moisture determinations are made every two days during the growing season and also observations on the percentage of shedding of bolls and squares. In connection with the work important data were secured on the water requirement of the cotton plant. It appears that the maximum quantity of water is needed during August and that the amount available in July and September should be nearly the same. About one-third of the water required for the development of the cotton plant is used in August. Evidence was obtained that there may be some correlation between leaf area and the shedding of bolls. The study of the angular leaf spot of cotton was continued and a large quantity of data was secured.

The project on the cause of partial insolubility in water of potash salts was continued actively. A rapid method for the determination of potash was devised. The method includes treatment with sulphuric acid and heating to a blast-lamp temperature. The project now includes a study of the effect of iron and aluminum on the determination of potash. In connection with this work a beginning was made on the new project relating to methods of burning wood to prevent volatilization of potash. This seems to be a difficult matter, but the preliminary results indicate that some success may be had.

Work with Hatch and other funds.—The agronomy division conducted experiments with cotton, corn, small grains, rotations, hay crops, and soil management. These experiments were conducted at the main station and at both branch stations. Fertilizer experiments involved the use of 20 plats. Some variety work with corn and cotton and breeding experiments with cotton are also under way. The forage plants under observation included the soy bean, velvet beans, cowpeas, Sudan grass, sorghum, alfalfa, and clover. Observations on crops for pig pastures are in progress. With both corn and cotton it appeared that under the conditions of the experiment nitrogen and soil moisture are the chief limiting factors.

The horticultural division continued its work in breeding Irish potatoes. Many crosses were made. More than a bushel of mature seed balls were collected from an acre of potatoes. Breeding and cultural

experiments were in progress with apples, peaches, plums, grapes, and other fruit. In propagating grapes it was found that young wood will root quite readily, while old wood is less satisfactory for this purpose. Satisfactory results, in so far as root production is concerned, were obtained by girdling 1-year-old wood. Some observations were made on the proper time of pruning and effect of bleeding of the vines when improperly pruned. Cultural work was also carried on with strawberries, blackberries, and raspberries. A systematic study of the varieties of peaches in the western part of the State was begun and some work was also done on pecans. The division of botany and plant pathology conducted a study of cotton wilt and cotton-root knot in cooperation with this department. Certain varieties of cotton have been developed which are practically resistant to these diseases. Some superior strains of cotton seed have been developed as a result of breeding work. The plant-disease survey of the State was continued.

The animal-husbandry division carried on experiments in calf feeding, comparing ground and unground grain. The results showed no benefit which would equal the cost of grinding. Grazing experiments with pigs are also under way in an attempt to devise a rotation of crops adapted to local conditions and to determine the value of these crops for pork production. Wheat proved to be an excellent pasture for pigs. A comparison of corn meal and tankage with rice meal and tankage for fattening pigs indicated that rice meal is more economical than corn meal. In other pig-feeding experiments data were gathered on the value of soy beans and wheat middlings. Various rations were also tested for dairy cows in which evidence was obtained on the value of molasses for milk production. A study was begun of the cause of a peculiar gumming condition that sometimes develops in butter. No evidence has been obtained to indicate the connection of rations with this condition. Pasteurized cream is less likely to produce gummy butter than unpasteurized cream. No important difference was noted in the value of linyt and lintless cotton-seed hulls as a feed for dairy cows.

The general entomological work of the station included the study of the scale insects of South Carolina, the use of oils in spraying for these pests, and observations on harlequin cabbage bug, Argentine ants, cotton root louse, tent caterpillars, and miscellaneous insect pests. The heavy oil emulsions gave complete control of scale insects.

The chemical division began a study of nitrogen determination in manure and of lime in relation to the growth of legumes on various types of soil. Extensive fertilizer experiments at the branch stations were supervised by the chemical division. Experiments indicated that phosphorus and nitrogen are of more importance for corn, oats,

and cowpeas than is potash, but that soluble potash is of vital importance for the growth of cotton on sandy soils.

The following publications were received from this station during the year: Bulletin 181, Analyses of Commercial Fertilizers; 128, Potash; 183, Limestone and Marl Deposits of South Carolina; 185, Cotton—Varieties and Limiting Factor Tests; 186, Cotton—Varieties, Ear-Row, and Limiting Factor Tests; Circulars 27, Home Canning of Fruits and Vegetables; 28, The Cabbage Harlequin or Calico Bug; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	14,646.08
Farm products, including balance from previous year	2,224.95
 Total	 46,871.03

The South Carolina station is constantly becoming a more important factor in the understanding of agricultural problems and in the development of practical agriculture in the State. The work of the station is being developed so as to throw light upon the most urgent problems which the farmer has to meet.

SOUTH DAKOTA.

South Dakota Agricultural Experiment Station, *Brookings*.

J. W. WILSON, M. S. A., *Director*.

The year was a successful and prosperous one for the station. An increasing number of farmers visited the station to look over the experimental work. While thus far no direct support, except \$1,000 annually for printing popular bulletins, is received from the State by the main station, the legislature has assumed a generous attitude toward the station. The direct appropriation from the State for the maintenance of substations is \$11,000 annually, in addition to about \$2,000 received as income from public lands. An additional appropriation of \$1,500 per year is also granted for work with alfalfa. V. R. Jones was appointed assistant dairyman; otherwise there were no changes in the organization of the staff. The area at the main station used for experimental purposes amounts to about 130 acres.

Adams fund projects.—The study of the influence of rotations upon the maintenance of soil fertility was continued on 2 acres of ground devoted to nine different crops. Determinations were made

of the total organic and inorganic carbon in the plats. No organic matter is returned to the soil, but nitrogen, phosphoric acid, and potash are supplied in commercial fertilizers. It was noted that the nitrate plats were relatively weedy, that potash apparently did not affect the crop yields, while phosphoric acid proved to be the most important factor in the matter of yields and nitrogen of next importance. In connection with this work special methods were devised for the determination of carbon.

The investigation of plant correlations as affecting yielding capacity was continued actively. Selection was made at first on the basis of the whole plant and later on the basis of the length of the heads of grain. An attempt is being made to determine the correlation between long heads and high yields. Indications obtained during the year are to the effect that there is no close correlation between the length of the head and the yield. An attempt is also being made to determine whether there is any correlation between variety and spacing and yield of alfalfa. Thus far the extent of the root system of alfalfa appears to depend more on spacing than on variety. The wheat used in this correlation work is of the Bluestem variety.

In continuing the study of water as a limiting factor in the growth of sweet clover, plants were grown in greenhouses in soils maintained under a moisture content varying from 18 to 32 per cent. The higher the moisture content the more dry matter produced in the crop and the higher the percentage of soil moisture the more water required per unit of dry matter. A greater efficiency of water was found on highly fertile soils than on poor soils. The water requirements as determined in the field were higher than the values obtained in greenhouses.

The study of the effect of unbalanced rations upon the physiological condition of horses was nearly completed during the year. All of the horses used in this experiment have been killed and careful autopsies made. It has been clearly shown that navicular disease, side bones, spavins, and other bone diseases and deformities may result from deficient feeding. In fact, all of the horses developed navicular disease. The bone structure was found to be greatly wasted, and tissue covering the joints was rapidly disappearing and the synovial fluid was becoming thickened. Many cases of ankylosis were found, and adhesions occurred in the intestines. No lesions, however, were produced in the heart, lungs, liver, or stomach. Incidentally, it was found that hairlessness in pigs may result from an exclusive corn ration.

The investigation of the rôle of water in the ration of the dairy cow was carried forward with satisfactory results and the work was practically completed. In order to determine the effect of giving cows one-half the normal amount of water the cows were main-

tained for a preliminary period on a full water ration and then for 10 days on one-half of normal water ration. The body temperature was affected by the amount of water received. It appears that large amounts of water lower the body temperature. Some evidence was obtained that deficiencies of water in the ration are made up by withdrawing the water from the body tissues, thereby causing a decomposition of the tissue and an elevation of body temperature. A deficiency of water seemed to disturb the mineral metabolism but did not affect either the composition or the amount of milk.

Further progress was made in the breeding of hardy fruits. This project has been restricted to a study of sterility, fertility, hybridization, and immunity of plums, pears, and apples and hybridization of blackberries, dewberries, and strawberries. One decidedly resistant variety of pear has been produced. Extensive crossing is being carried on to obtain greater hardiness. In this work about 1,000 crosses have been made resulting in at least 100 hybrid seedlings which give sufficient promise to warrant further propagation. Several experimental hardy seedling apples have also been secured as the result of breeding and selection, and at least four varieties of plums produced at the station gave great promise with reference to their quality and hardiness.

Work with Hatch and other funds.—The general work of the agronomy department involved a large variety of experiments. It was found that sweet-clover seed was fairly well scarified by passing through a good huller. A comparison is being carried out between grain farming and the live-stock system of farming, the results thus far obtained being decidedly in favor of live stock. In corn-breeding experiments, an attempt is being made to determine whether there are any correlations between high-protein content in the kernel and the total yield of protein per acre. The best results with flax were obtained from some of the North Dakota varieties. Experiments are also under way with Manchurian varieties of soy beans as a source of oil and forage. Some breeding work was carried on with alfalfa and cereals.

In an experiment to learn the effect of the depth of plowing on a set of rotation plats, no differences in yield were noted as a result of plowing to depths varying from 4 to 14 inches.

Little difference in yield was noted between Vale, Grimm, and Turkestan varieties of alfalfa, but the strains of *Medicago falcata* indicate that this species may not yield as large amounts of hay as the varieties just mentioned. A study of winter grains for South Dakota indicated that both winter wheat and rye have certain advantages over the same grains planted in the spring in that they may ripen early enough to avoid the effects of drought, hailstorms, and rust. They are, however, at the disadvantage of being exposed

to severe injury from winter freezing and the attacks of rabbits. At the Vivian substation better results were obtained with alfalfa from seeding with a nurse crop than seeding without a nurse crop, and from 6-inch and early plowing rather than 3-inch and late plowing.

A number of experiments in animal husbandry were conducted during the year. A test was made of the value of corn cut at different stages of growth for use as silage. The four stages of growth at which the corn was cut were before the ears were formed, in the milk stage, in the dough stage, and in the dent stage. While the results were not conclusive as to the best stage at which to cut corn for silage, all steers fed for three months on silage and then for three months on grain and hay made better gains than steers which were fed six months on grain and hay.

In an experiment with corn silage for lambs it appeared that this feed is not satisfactory as a sole ration for young lambs. An experiment is also in progress in crossing Siberian sheep on Shropshire, Hampshire, and Rambouillet ewes in an attempt to produce in the hybrids a sheep with the hardiness of the Siberian breed without losing the desirable wool characters of the English breed.

The general work of the station in dairy husbandry included experiments in cream pasteurization, ice making on the farm, and a study of milking machines. Samples of cream were pasteurized at temperatures of 140°, 160°, and 180° F. These samples were analyzed, subjected to bacteriological studies, and examined for the size of the fat globules both before and after pasteurization. It was found that high temperatures were most efficient in pasteurization and that the butter from such cream keeps better, but that the method is more expensive. In making ice on the farm the method of freezing water in cans in winter proved satisfactory and the ice appeared to be of sanitary quality. The best method was found to consist in filling the can to within about 3 inches of the top. After this water has been frozen the can may be completely filled and allowed to freeze. In this manner bulging of the surface of the ice is prevented. An elaborate series of experiments is being conducted with milking machines, 7 different types being in daily operation. No bad effect upon the udders has been observed from the milking machines. The conclusion has been reached that the successful operation of milking machines depends more on the cow and operator than on the machine. Some cows may be successfully milked by any milking machine, while other cows are not adapted to milking by machines.

The horticultural work under the support of Hatch and other funds included several experiments in breeding hardy fruits and ornamental plants, while species of grapes were crossed with Concord, Wigwam, and other cultivated varieties. Some crossing and other selection work was also carried on with gooseberries and currants.

Sand cherries continued to receive much attention. They are being used as stocks and for crossing with related species. In work with ornamentals progress was made with roses, clematis, iris, honeysuckle, and various other plants. In breeding work with alfalfa the Cossack variety proved to be the best for the region around Brookings. Farther west the Semipalatinsk forms of *Medicago fal-cata* gave excellent results. About 12 varieties of this species are being propagated.

The publications received from this station during the year were as follows: Bulletins 160, Silage and Grains for Steers; 161, Winter Grain in South Dakota; 162, First Annual Report of Vivian Experiment and Demonstration Farm; 163, Comparative Yields of Hay from Several Varieties and Strains of Alfalfa at Brookings, Highmore, Cottonwood, and Eureka; 164, Making Butter and Cheese on the Farm; and the Annual Reports for 1914 and 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation-----	13,000.00
Farm products, including balance from previous year--	6,589.95
Miscellaneous, including balance from previous year--	7,015.82
 Total-----	 56,605.77

The South Dakota station is successfully carrying forward several lines of investigation and is meeting all reasonable expectations. The members of the staff are maintaining close connection with the farmers of the State while devoting their energies to research upon problems which are of prime importance to agriculture.

TENNESSEE.

Tennessee Agricultural Experiment Station, Knoxville.

H. A. MORGAN, B. S. A., *Director.*

The Tennessee station enjoyed a prosperous year. The land known as the Cherokee tract, about the title of which some legal action had been pending, was definitely turned over to the station. The tract, including fencing and buildings, cost \$150,000. This area will greatly increase the land at the disposal of the station, and a beginning has already been made in arranging for permanent plantings, orchards, and rotation plats. The State legislature appropriated \$5,000 for the Central Tennessee substation and \$10,000 for the West Tennessee substation. Types of beef and dairy Shorthorn cattle were purchased for use in experiments at the West Tennessee substation. N. Jacob accepted a position as State veterinarian and was succeeded as station veterinarian by W. C. Shaw.

Adams fund projects.—The study of the form of nitrogen in the nodules of legumes was continued actively. An attempt was made to determine not only the method of nitrogen assimilation but the manner in which the nitrogen in bacteria becomes available to the host plant. Some evidence was obtained indicating that ammonia first appears in tubercles on soy-bean plants grown in ammonia-free media. An attempt was made to determine whether clover plants can obtain nitrogen when bacteria are excluded from their roots by parchment membranes without definite results thus far.

The bacterial decomposition of organic matter was studied with reference to the influence of various products of bacterial action on the rate of decomposition of certain organic material. Thus far the results indicate that organic acids encourage decay. The liberation of carbon dioxid was taken as an index of decomposition. Cotton-seed meal and wheat straw were used as experimental materials in sand cultures, to which various organic acids were added.

The investigation of the carbonaceous food requirements of Azotobacter brought forth evidence that bacteria can not use the carbon dioxid of the air. Various sources of carbon were tested, and it was found that the organisms could derive their carbon from ether, dilute alcohol, acetic acid, formaldehyde, and various other substances. A study of cultures of Azotobacter from various localities showed many differences of form which, however, tended to disappear under identical cultural conditions. A beginning was made on the cooperative project between the departments of bacteriology and soils on the nitrogen gathering and transforming coefficients of two types of Tennessee soils. This work is being conducted in tanks.

Considerable progress was made in the investigation of humus, especially in methods for the estimation of humus. The measure of the carbon dioxid evolution, as controlled by a constant factor, is considered the best method of procedure. The work with various crops in cylinders in the field was continued and the results of five years' tests were tabulated. Some interesting data regarding nitrogen conservation were thus obtained. The comparative economy of different forms of nitrogen is under study. Results were obtained indicating that it may be possible to determine by the usual method of extraction with ammonia the humus content of the soil with sufficient accuracy.

The study of the decomposition of calcium and magnesium carbonates in soils under field conditions progressed with encouraging results. In connection with this work considerable effort was devoted to a study of the carbonation of burnt lime. Magnesium carbonate was found to be transformed quickly to silicate under the conditions of the experiment. The conclusion was therefore drawn that in

humid soils magnesium carbonate does not exist under normal conditions. A new lysimeter equipment was established for the study of the activities of the oxides and several carbonate forms of calcium and magnesium.

Studies were continued on the life history of the organism of clover anthracnose and of the methods of infection. The spores appear to be killed by a few minutes' exposure to a temperature of 45° C. They are also quite easily destroyed by exposure to direct sunlight. These facts are believed to explain the occasional almost total disappearance of the disease. In periods of extreme heat living spores are found only in lesions in shaded plants. Preliminary experiments indicate that infection occurs much more readily in actively growing tissue. A few resistant strains of clover have been secured and the seed of these strains is being distributed throughout the State. The study of Spirogyra in connection with this project has shown that Spirogyra may be attacked by a species of Pythium and that the growth and behavior of the parasite may be readily studied in living strands of Spirogyra under the microscope. This study it is hoped will offer some explanation of the nature of infection and resistance to disease.

Further work was done on the project relating to pear blight. Seed was obtained from France and a number of seedlings thus produced have been obtained for experiments on relative resistance. Seed has also been secured from California and elsewhere for comparison.

The two projects on the cause of tomato wilt and on the resistance of tomato to Fusarium were conducted in close connection. Particular attention is being given to the physiology of resistance. The fungus is being studied from a morphological standpoint and several forms of Fusarium have been found differing greatly in virulence. Excellent progress was made in the selection for blight resistance. Some of the varieties are now being tested on a large scale. Incidentally some attention is being given to the inheritance of various characters of tomato fruits as related to disease resistance. The botanical study of Japanese clover was continued with encouraging results. This work is done chiefly at Jackson. A number of species of Lespedeza have been brought together and attempts are being made to cross annual and perennial species. The morphological characters of the plant are receiving attention and also its cultural requirements and life history. One leafy strain, with upright habit of growth, and a prostrate form have been isolated.

Experiments with the peach borer were continued with special reference to rational methods of attacking the pest. Studies were made of the life history of the insect from the egg on the leaf to the

borer on the tree. Data are being accumulated on the normal mode of entrance into the tree. The use of tree protectors was found to be unsatisfactory. Mounding the earth about the bases of the trees produced some benefit but did not entirely eliminate the attack. Interesting results were secured in the study of the hog louse. Adult lice are placed on uninfested hogs and studied with reference to the number of eggs and the time of depositing them. Eggs have been carefully studied through the incubation period and dates of hatching observed. Notes have also been taken on the molting periods. In connection with the life-history studies it has been found that the pest may easily be controlled by the use of oil which kills both parasites and eggs.

In the study of a temperature law in crop production a search was made for factors that determined the length of time required for soy beans to reach a given stage. In this work records were obtained from 15 Weather Bureau stations in various parts of the country. The subject is being studied by means of correlation tests. It appears that air temperature is responsible for about half of the variation. The temperature of the first nine inches of the soil appears to have little effect, but the deep soil temperature is possibly responsible for a part of the variation. On the whole the results thus far secured indicate a higher correlation between soil temperatures and certain stages of growth than between air temperatures and these same stages.

Work with Hatch and other funds.—The department of chemistry and agronomy continued essentially the same lines of work as have been in force for several years. The projects included variety trials of farm crops, fertilizer, manure, and liming experiments for individual crops and in rotations, tobacco investigations, tillage experiments, variety tests, and pasture studies. The effect of the cowpea on soil fertility is receiving much attention, particularly with reference to the effect of cowpeas on following crops. At the substations, cultural experiments in variety tests are carried on quite extensively. It was found during the year that one variety of soy beans was well inoculated, while another variety seldom showed nodules. The tobacco investigations were largely studies of rotation suitable to this crop. The work has been in progress for several years. In connection with the cowpea work selection of individual plants for crop improvement has been made. Some experiments with crop management are in progress at the Middle Tennessee substation and a soil survey is also in progress.

In the department of animal husbandry the important experimental work included the determination of beef yield per acre from various forage crops fed to steers, the economical wintering of stock or cattle, feeding of cottonseed meal to hogs, influence of winter

forage on the gain in hogs, and the effect of sudden changes of rations upon the gains of steers. At the West Tennessee station, two Shorthorn herds of the beef and milking type have been established to study the influence of type on production. Additions were also made to the Percheron Foundation studs. A test of milking machines is in progress. In previous experiments the test was continued for 45-day periods without appreciable decrease in the milk flow. Further tests will be made during periods of six months. On the newly acquired Cherokee tract a new barn is to be erected for the use of the animal husbandry department.

In steer-feeding experiments with reference to farm returns it was found that soy beans and barley ranked ahead of other combinations in the amount of food material produced per acre and that soy beans ranked ahead of cowpeas in the production of grain. The rotation in which soy beans were used produced an average of 57 pounds more beef per acre than that in which cowpeas were used and 74 pounds more than that in which corn was used. The average prices received for the crops marketed through the steers were \$1.40 per bushel for soy beans, \$1.60 per bushel for cowpeas, \$1.39 for wheat, \$0.57 for oats, \$1.02 for barley, and \$1 for corn.

The horticultural department continued a study of the root development of apple trees as affected by different kinds of soil. Attention was also given to the influence of climate on seed potatoes and fertilizer experiments in orchards. The department is cooperating with the department of entomology in the investigation of a peach-tree borer and with the botanical department in the study of pear blight. A considerable tract of land is being prepared on the Cherokee tract for horticultural investigations. It is expected that the tract will offer facilities for the study of elevation and position in relation to frost injury. In the old station orchard spraying experiments were conducted with miscible oils as compared with lime-sulphur as a winter treatment against San Jose scale. Some work was also done with truck crops and soil improvement in connection with the horticultural investigations at the West Tennessee substation.

Miscellaneous experiments conducted by the station included a test of methods of weed eradication, cotton breeding, variety tests, and cold-storage experiments with sweet potatoes and a test of fall planting of Irish potatoes. It was found that chickweed is readily destroyed by heavy orchard grass sod.

The following publications were received from this station during the year: Bulletins 113, The North American Fever Tick—Notes on Life History; 114, Relation of Steer Feeding to Farm Returns; and 115, Factors Influencing the Lime and Magnesia Requirements of Soils—A Method for the Determination of the Immediate Lime Requirements.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
State appropriation-----	19,527.64
Farm products, including balance from previous year-----	10,425.27
 Total-----	 59,952.91

The Tennessee station is making steady progress in its bacteriological, botanical, chemical, agronomic, and entomological investigations. The facilities of the station for agronomic and horticultural work will be greatly improved by the acquisition of the new Cherokee farm. It has strong support from the agricultural interests of the State.

TEXAS.

Texas Agricultural Experiment Station, College Station.

B. YOUNGBLOOD, M. S., *Director.*

The year was a prosperous one for the Texas station. Progress was made in various lines, and the working force of the station was strengthened by several appointments. The State appropriated \$135,000 for the station, the largest grant made in the history of the station. Relations with the college of agriculture were very satisfactory, mutual cooperation prevailing at all points of contact. Dr. E. P. Humbert was appointed to take charge of the new division of plant breeding. W. Newell, entomologist of the station, resigned and his place was filled by the promotion of F. B. Paddock. J. J. Taubenhaus was appointed plant pathologist and physiologist. Additional buildings for the various substations were erected during the year, including a model barn at Denton. Land was purchased for the goat substation near Sonora. An appropriation of \$10,000 for the biennium to supplant private contributions toward this purpose was made by the State. A new agronomy barn was erected on the station farm.

Adams fund projects.—The investigation of the nutritive value of feeds was continued with particular reference to the nitrogen-free extract of feeds studied in connection with digestion experiments. The feeds used in this work during the year included prairie hay, Sudan-grass hay, wheat bran, shorts, and peanut hay. Some digestion experiments with sugar, starch, and pentosans were also conducted. A method for calculating productive value of coarse and concentrated feeds was worked out. The production coefficient was derived by multiplying the digestion coefficient by the factor which converts nutrients into fat value after which a correction is applied to crude fiber and nitrogen-free extract.

Work on the project on soils was limited largely to the studies of the rate of nitrification and ammonification of soils differently treated, both cropped and uncropped. Much less nitrate was formed in the cropped than in the uncropped soils. The relation between potash and phosphoric acid in soils and crops is being studied in pot experiments. In studying the effect of various substances upon the availability of soil phosphates, it was found that vegetable matter in some cases causes a gain in the amount of phosphoric acid taken up by the crop. The presence of carbonate of lime or vegetable matter may bring about differences in the quantity of assimilated phosphoric acid from soils containing equal quantities of phosphoric acid. The oxidation of organic compounds in the soil was also studied. Cottonseed meal appears to be oxidized to the extent of 10 per cent in one day and 30 per cent in four days. In dry soils organic matter was oxidized rapidly. Carbonate of lime had little or no effect upon the oxidation of organic substances. In a study of the moisture relations of soils it was found that both cultivation and manure increase the quantity of water held by the soil at the end of wet periods and diminished the loss by evaporation.

The study of diseases of watermelon was continued. There appear to be several important ones, among which the blossom-end rot is receiving much attention. About 25 acres of cucurbits are grown at Prairie View, where this project is being carried on. A beginning was also made in the study of sweet-potato diseases upon the same tract of land.

The attempt to study bee inheritance in an isolated locality was brought to a close during the year. It was found that there were bees on neighboring farms and that the purity of the strains could no longer be preserved by the method of geographical isolation. The results of this experiment have not been tabulated. The investigation of the life history of aphids was confined to four important species of which the cotton louse is receiving most attention. This study involves the determination of the life history, observations on alternate host plants, and studies in greenhouses under controlled conditions. An attempt is also being made to determine whether food plants affect the size and color of plant lice.

Considerable difficulty was encountered in continuing the study of inheritance in cotton. The material obtained from self-pollination is, however, considered reliable and of much importance. In this work attention was given to a single character rather than to the selection of an ideal plant. Some strains, low and high in oil, have been obtained.

Numerous hybrids have been obtained between dewberries and raspberries, but all had proved to be sterile until the year under report, when a few of the hybrids fruited.

Little progress was made in the investigation of swamp fever or infectious anemia of horses. An attempt was made to find the means of transmission. In these experiments two kinds of ticks were tested without result. Some work was also done on methods of diagnosing the disease.

Work with Hatch and other funds.—The animal-husbandry section conducted a large number of experiments. A beginning was made in a feeding experiment with poultry, comparing cottonseed meal with other forms of nitrogenous feeds. The sheep experiments are conducted largely at the Spur substation and consist in breeding experiments for the purpose of securing the most profitable type for lamb production under Texas conditions. Encouraging results were obtained from Lincoln sheep. Shropshire and Romney Marsh breeds were also used in the experiment. Experiments with goats will soon be undertaken at the new substation established for this purpose. A cattle-feeding experiment was undertaken for the purpose of comparing cottonseed meal, cold-pressed cottonseed cake, and peanut meal. Feeding and grazing experiments are also under way with hogs. In a comparative test of various rations for steers a ration of cottonseed meal, silage, and ground milo maize gave the best results. The experiment as a whole showed that there is little profit in cattle feeding in Texas under present conditions, unless feeder stock can be obtained at lower prices. In fattening experiments with lambs it was found that good silage can be safely fed to lambs but that it can not profitably constitute the only roughage.

The agronomy section conducted experiments in plowing at different depths. The results were not altogether harmonious. Deep plowing appears to give the better stand with most crops. Japanese sugar cane gives much promise as a forage crop for Texas.

The horticultural section continued its work along the same lines as in the previous year. A seedling orchard of Indian peach bore during the previous year, but for some unknown reason the strain does not appear promising at present. Good results were obtained in the cure of crown gall on apples and peaches by removing the diseased tissue and disinfecting with copper sulphate.

The chemical section investigated the nutritive value of pecans, honey, and cottonseed meal. A large number of miscellaneous analyses were made, particularly of soils secured during the progress of the soil survey. The control work in connection with commercial fertilizers and feeding stuffs occupied much of the time of the chemical section.

The section of plant pathology began a study of a new disease of privet from which two organisms were isolated. It is proposed also to investigate cotton-root rot and corn-ear mold.

The entomological section devoted its energies largely to a study of the turnip louse, harlequin cabbage bug, cowpea weevil, and the distribution of a number of injurious insects. The louse which is most injurious to turnips in Texas was found to be *Aphis pseudobrassice* and not the cabbage louse, as was formerly supposed. This insect causes injury to turnips, cabbage, mustard, cauliflower, rape, ruta-baga, and kale. A number of parasites have been found. The pest is best controlled by spraying with a solution of laundry soap. Some attention was also given to the insect enemies of Sudan grass and to the enforcement of the State foul-brood law.

The experimental work of the veterinary section was confined largely to Texas fever and bighead of goats. In this work 514 cattle were given a preventive inoculation.

The feed-control section made a study of peanut milling. It appears that from a ton of peanuts, as furnished to the mill by farmers, about 65 gallons of oil are obtained and 1,200 pounds of peanut cake.

The following publications were received from this station during the year: Bulletins 171, Losses of Moisture and Plant Food by Percolation; 173, The Composition of the Soils of the Texas Panhandle; 174, The Effect of Organic Compounds in Pot Experiments; 175, Distribution and Digestibility of the Pentosans of Feeds; 176, Commercial Fertilizers in 1914-15; 177, Commercial Feeding Stuffs, 1914-15; 178, Effect of the Additions on Availability of Soil Phosphates; 179, The Harlequin Cabbage Bug; 180, The Turnip Louse; 181, Oxidation of Organic Compounds in the Soil; 182, Steer Feeding; 183, Moisture Relations of Some Texas Soils; 186, Fattening Lambs; Circulars 7, Insect Enemies of Sudan Grass; 8, The Texas Foul-brood Law; 9, The Story of Three Pigs; 10, Housing Farm Implements; 11, Foul-brood Regulations Effective March 1, 1916; 12, Progress in Peanut Milling; and the Annual Report for 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	140,582.50
Individuals	531.93
Farm products, including balance from previous year	572.00
Miscellaneous, including balance from previous year	20,166.90
Total	191,853.33

The Texas station has been considerably strengthened during the year by new appointments and by the provision of minor buildings. It is doing good work and is well administered. Its strength and following in the State are increasing each year.

UTAH.

Utah Agricultural Experiment Station, *Logan*.

E. D. BALL, Ph. D., *Director*.

There were a number of important changes on the staff of the Utah station during the year. After a service of nine years as director of the station E. D. Ball resigned and was succeeded by F. S. Harris. E. G. Peterson succeeded J. A. Widtsoe as president of the college; R. Stewart, chemist, was succeeded by J. E. Greaves; E. P. Taylor was appointed horticulturist, and O. W. Israelsen was placed in charge of the department of irrigation and drainage. A new building for chemistry and physics, in which the station shares, was completed and occupied during the year. The bacteriological and chemical departments of the station have quarters in the new building. An appropriation of \$6,000 for a sewage system and \$30,000 for an addition to the power plant were granted the college by the State board of agriculture.

Adams fund projects.—The study of the life history of the wheat-straw worm was continued actively, an attempt being made to complete the life history of the first brood which appears early in the spring. This brood injures from 20 to 30 per cent of the wheat crop and is followed by another brood. Grain from many districts of the State was investigated. Observations were also made of the effect of the time of planting upon the control of the pest. The data thus obtained indicate that the insect can be best held in check by planting wheat at the proper time. A beginning was made in investigating insects which injure alfalfa seed. This study includes work on thrips, seed chalcis fly, and the common plant bug. Observations were carried on principally in Emery County. Irrigation combined with late fall cultivation is beneficial in holding the insects in check. Data are being collected on the life history of all three species.

Sugar-beet pests continued to receive a large amount of attention. The work was confined to the beet-leaf hopper, which appeared to be responsible for leaf blight or curl, acting as a carrier of the pathogenic organism. The application of irrigation water at different times appeared not to affect the insect, but it was incidentally learned that a lack of moisture combined with a high temperature reduced the resistance of the beet. Further attention will be given to the distribution, breeding place, and prevalence of the insect. It is supposed to breed on desert plants. The study will perhaps give a basis for predicting outbreaks of the pest.

In continuing a study of factors influencing the bacterial activity of soils much attention was given to the stimulating influence of arsenic on nitrogen fixers in the soil. This stimulation was found to be temporary and entirely disappeared, showing a depression of

nitrogen fixation unless the soils were aerated. In most cases the influence of arsenic disappeared after 30 to 40 days. One species of Azotobacter was stimulated by arsenic. When the soil was heated to a temperature which destroyed the protozoa, little stimulation from arsenic was noted. Attention was also given to the influence of soluble salts, especially chlorids, carbonates, sulphates, and nitrates of soda, potash, calcium, magnesium, manganese, and iron on the ammonifying power of soils. Chlorids were found to be most toxic.

The project on the formation of nitrates in soils has been practically completed. The data accumulated during the course of the work will be sifted and analyzed with reference to the possibility of a correlation between chemical and bacteriological phenomena.

In further work on methods of improving egg production the data secured since 1907 were summarized together with other American egg records. An attempt is being made to find a basis for measuring the laying capacity. Much attention was given also to a study of the climatic influence of different seasons. The years 1911, 1914, and 1915 were very poor from the standpoint of egg production. The cause of this seasonal variation has not been determined, but it was noticed that the egg yields were low as well as the hatchability and subsequent growing power of the chicks. Additional evidence was obtained that breeding experiments for egg production must be carried over a long period in order to eliminate seasonal effects.

Work on the project relating to artificial incubation of eggs was somewhat delayed by troubles experienced in operating the electrically heated incubator. The incubator was remodeled and a larger blower installed, which enables the air to be moved through the machine rapidly or slowly, as desired, thus guaranteeing a practically uniform temperature. Devices were also perfected for controlling the humidity.

The study of the action of alkali was begun during the year. It was found that a given concentration of an alkaline salt does not have the same toxicity in all soils. For example, less alkali was required to kill plants in a sandy soil without organic matter than in a loam soil. An attempt is being made to discover the factors concerned in the toxicity of soluble salts.

Work with Hatch and other funds.—The general entomological work of the station included a study of the nematodes of sugar beets, apple-leaf roller, and alfalfa weevil. Considerable progress was made in determining the insecticides most effective against the apple-leaf roller. The alfalfa weevil is being studied with relation to temperature conditions at high altitudes. In further work with nema-

todes of beets it was found best to recommend that beet growing be temporarily abandoned on areas on which nematodes prevail.

The chemical division worked on bacterial activities of soils and on the composition of various waters and native plants. It was shown that ammonia and nitrates increase steadily with the amount of manure added up to a certain point. This is explained as due probably to the formation of proteid substances within the organisms rather than to denitrification. Samples of water were taken from many of the most important streams and wells for analysis in order to learn which waters carry alkali in quantities sufficient to render their use objectionable for irrigation purposes. In studies of the composition of native plants it was found that sage brush contains about 108 pounds of potash per ton, and greasewood ash 252 pounds of potash. These plants are therefore considered as possible sources of potash.

The department of botany and plant pathology gave a large amount of attention to potato diseases and also began a study of California peach blight and a disease survey of the State. The effects of various treatments on Rhizoctonia were also investigated. Field surveys are in progress in various parts of the State to determine the effect of different treatments on the control of Fusarium wilt and Rhizoctonia. Newly broken alfalfa land seems to be particularly well adapted for the control of these diseases. In studying the sclerotia found during the course of this work comparative tests were made with formalin and corrosive sublimate. About equally good results were obtained from these fungicides. A hot-water treatment also gave good results. Submersion for seven minutes in water at a temperature of 54° C. killed the pathogenic organisms but did not injure the potatoes. Some attention was also given to blackleg of potatoes.

The department of physics and meteorology investigated the susceptibility of peaches to cold, using an apparatus specially constructed for this purpose. The apparatus consists of a circular, double-walled tank built in two halves, divided vertically, to be placed about a tree and then cooled to the required temperature. Some attention was also given to the effect of low temperatures upon fruit buds.

The horticultural work of the station involved a study of orchard irrigation, the bearing habits of trees, pruning, and the variation in minimum temperatures due to the topography of mountain valleys in relation to fruit growing. Water was applied to trees at different times and in different amounts. The root system of a tree on each plat was later exposed and carefully studied. It was found that trees without irrigation sent the roots down no deeper than those

irrigated and did not show as great a spread of roots. The bearing habits of trees are under study on a 15-acre private orchard. In a study of the variation in minimum temperatures due to topography it was found that fruit districts located at the mouth of a canyon experienced a higher minimum temperature than localities of similar elevation beyond the influence of canyon breezes. The minimum temperatures observed on bench lands were 6° to 10° F. warmer than valley bottoms by reason of the drainage of the cold air to the low areas during calm, frosty nights.

In pruning experiments it was found that apple trees which were pruned to induce a spreading habit by cutting back the terminal growth to lateral branches produced a greater annual twig growth than trees which were similarly pruned except that the terminal growth was untouched. Trees pruned during the dormant period and also in summer produced a greater annual twig growth than trees pruned only during the dormant season. Summer pruning appeared to depress the yield of marketable fruit below that of trees pruned in winter. In irrigating peaches it was found that frequent applications of water on gravelly loam soil at intervals of 7 or 8 days produced a more continuous and greater total twig growth than the same amount of water applied at intervals of 10 to 12 days.

The agronomic and irrigation work of the station included irrigation experiments with wheat, potatoes, alfalfa, and sugar beets; breeding experiments with sugar beets and potatoes, a study of the commercial production of sugar-beet seed, and general observations on dry farming and the ground-water sources of the State. Some attention was also given to cultural and rotation experiments involving the use of wheat, oats, barley, barnyard manure, and green manuring. Evaporation studies were also carried on with reference to the movement of soil moisture and soluble salts. In irrigation experiments with corn it was found that from 20 to 30 inches of water give better results than 40 inches, which appears to be an excessive amount. On the nitrate plats at the station the moisture, nitrates, and total soluble salts are determined three times annually. A strain of sugar-beet seed has been developed which is well adapted to Utah conditions. A study of the principles underlying the successful practice of dry farming is being continued at the Nephi substation and also at Cedar City and Kanab.

The department of animal husbandry conducted experiments in the use of silage in connection with an alfalfa and grain ration for dairy cows. The results indicated that corn silage may come to play an important part in the ration for cows in Utah. Three pounds of corn silage were found to be equal to 1 pound of alfalfa hay. An experiment in hog feeding was also begun, comparing the feeding

value of chopped and steam-rolled barley with the whole grain. Attention is being given in this work to the feeding value of beet molasses for hogs. The station also did some work on the methods of improving the horses of the State and on the artificial insemination of mares.

The following publications were received from this station during the year: Bulletins 139, The Movement of Soluble Salts with the Soil Moisture; 140, The Summer Pruning of a Young Bearing Apple Orchard; 141, Variation in Minimum Temperature Due to the Topography of a Mountain Valley In Its Relation to Fruit Growing; 142, Irrigation of Peaches; Circulars 18, Better Horses for Utah; 19, Licensed Stallions in Utah During the Season of 1915; and 20, Capsule Method of Breeding Mares.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	12,670.15
Farm products	4,297.04
Balance from previous year, miscellaneous	277.83
 Total	 47,245.02

The research work and organization of the Utah station are in excellent condition, reflecting much credit on the administration of the station for the past nine years. The station has developed into a strong and efficient institution.

VERMONT.

Vermont Agricultural Experiment Station, *Burlington*.

J. L. HILLS, Sc. D., *Director*.

The work of the station proceeded without material change. A. A. Borland, in charge of animal husbandry, was succeeded by G. F. E. Story. C. G. Williamson, assistant chemist, and E. L. Baker, computer, severed their connection with the station. In accordance with the State law, the station is required to make free analyses of agricultural materials for residents of Vermont. The State, however, has not made an appropriation for such work. The number of requests for analyses of various materials has increased until this work is thought to be somewhat of a burden upon the station. The trustees of the station, therefore, will make a request that the general assembly at its next session appropriate funds to support this work. The work of the station has been placed entirely on a project basis.

Adams fund projects.—In the study of potato scab several varieties of potatoes have been tested for resistance to the disease. The effect of coal ashes, lime, salt, nitrate of soda, sulphur, and potash upon

the skin of the potato was also investigated with reference to their influence upon the development of scab. A considerable variation in the thickness of the skin of the potato was found. During the past three years field studies have shown that only the russet varieties are relatively free from scab. Studies of the skin of young and mature tubers indicate that the thickness of the skin is quite a reliable measure of resistance to scab. The lenticels also appeared to be connected with scab resistance. Some experiments were also conducted with reference to the effect of the time of planting and of soil treatment with fertilizers in their effect upon scab. No effective soil treatment for scab has been found. Sulphur appears to be as efficient in preventing scab as formaldehyde and other treatments. It appears not to be practicable to add ammonium sulphate in sufficient quantity to prevent scab.

Further study on the stimulating effect of Bordeaux mixture on potatoes indicated that the favorable effect obtained from the use of this fungicide on potato plants is due, to a larger extent than has been heretofore appreciated, to the prevention of tip burn. The experimental work of the station on this project during the year related largely to this phase in the development of the potato plant. The control of flea beetles by the use of Bordeaux mixture may also be connected with the apparent stimulating effect of the fungicide. An investigation was made of the cause of tip burn by means of shading and watering experiments. Trouble appears to be due to excessive sunlight causing a yellowing and bleaching of the chlorophyll. Copper compounds applied to the leaves retarded the yellowing.

In the project on the storage of sugars and other carbohydrates in the wood and inner bark of the maple and other trees, work was continued on the analysis of the wood, particularly that of the maple. Maple sap and sugar were also sent in from several localities for study in connection with this investigation. Some further analytical work remains to be done on the bark but the project is practically completed.

The study of the nutritive value of milk led to some interesting results. In order to gain an idea of the value of different grades of milk in infant feeding, experiments were conducted with 168 young pigs, the digestive functions of these animals being somewhat similar to those of the infant. The grades of milk were based on the percentage of fat, but the size of the fat globule was also taken into consideration. The results indicate that milk with a relatively low fat content is more readily digested but that the size of the fat globules has no apparent effect upon digestibility. The investigation of the

fat content of milk as related to digestibility has thus been completed and attention will now be given to the protein content of the milk.

Work was continued in the investigation of the food cost of metabolism. In this experiment three cows were used. The plan of the experiment involves determining as accurately as may be the average or normal weight of a cow, after which the cow is fed so as to increase her weight 150 pounds. This feeding period is then followed by another in which the ration is so regulated that the cow will lose weight until she falls 150 pounds below normal. The experiment is thus designed to imitate quite closely a common farm practice in allowing great variations in weight in cattle by under-feeding in winter and overfeeding in summer. The results indicate that some cattle may maintain themselves at a remarkably low cost on a varying ration of this sort. A closely related project on maintenance ration for dairy cows was continued, taking account carefully of the nutrients used for the fetus and for milk production as well as for maintenance when dry. In this experiment 11 cows are maintained in the barn entirely.

The study of the effect of feeding different amounts of digestible protein to cows was continued on a smaller number of animals than heretofore, for the reason that the variation in the amount of protein was not showing any striking results. Even after the protein was reduced to $1\frac{1}{4}$ pounds per thousand pounds of live weight, there was no falling off in weight or milk production. Careful physical examinations are made at intervals, but thus far no ill effects have been shown from the low protein ration.

All of the nine native species of Vermont blackberries have been used in studies of the origin of species and development and improvement by hybridization. These crossing experiments were carried out to determine whether the so-called native species are themselves hybrids or true species. Several of the supposed species have proved to be merely hybrids. The project involves a study of inheritance as well as taxonomy and will be carried on with species of both Rubus and Viola. During the year practically no work was done on Viola. The extent of sterility in Rubus varies greatly for different species and hybrids. An attempt is being made to determine the effect of external factors on the growth and development of different species of blackberries when maintained under controlled greenhouse conditions.

The investigation of shade tolerance for forest trees was confined largely to study of conditions best suited to the development of white-pine seedlings. In this work the physical conditions in the woods under lath shades and under cheesecloth were carefully studied, especially during the summer months. The seedlings are transplanted

under shade at the age of 1 year. The effect of shade appears to be more pronounced in the case of seedlings which have been grown close together. The relation of evaporation to transpiration is also under study. The tolerance of seedling trees to shade appears to be partly a question of root competition and moisture and plant food rather than of light. Both pine and oak seedlings have been studied. The pine has the power of controlling its evaporation better than does the oak.

The use of carbon dioxid in forcing plants was continued, using radishes, strawberries, chard, lettuce, nasturtiums, potatoes, and other plants. An attempt was made to determine the optimum dosage. It was found that carbon dioxid applied above ground was beneficial to all these plants, but that some were more favorably affected than others. Analytical studies indicated an increase in the carbohydrates and a corresponding decrease in the protein of the plants as a result of treatment with carbon dioxid. The differences in this regard, however, were not large. Carbon dioxid appeared to act as a stimulant and to hasten maturity and increase the size of the plants.

The investigation of the cause of sterility in strawberries was carried on actively, attention being given to the influence of fertilizers, hybridization, and other factors. An attempt is being made to determine whether sex in strawberries is a Mendelian character. About 2,000 seedling plants are now under observation, some of them being in the second generation. The perfect forms are being self-fertilized to determine whether they come true. Experiments to determine the effect of fertilizers upon sterility are conducted in the greenhouse, using several different kinds of soil, with the aim of learning how sterility may be overcome.

Several years ago the station found that some guinea pigs had no blood complement. Breeding experiments have been carried on to determine whether this character is hereditary. The experiments conducted during the year involved numerous selective matings with reference to complement titration. Over 1,300 offspring were produced, the blood of which has been carefully studied. The character of absence of complement appears to be hereditary or nearly so. Only a trace of complement was found in the offspring of parents which themselves had no complement. In mating hybrid guinea pigs about 56 per cent of the offspring proved to be normal, while about 44 per cent were without complement.

Work with Hatch and other funds.—In connection with its soil studies, the station has devised a method for determining soil acidity. Evidence has been obtained that in Vermont soil acidity and the corresponding lime requirement is due to a colloidal absorption and

not to an actual mineral acidity. The chemical division is called upon to make numerous analyses and this work has considerably increased during the past two years. Some of the more important analyses of this sort involved the examination of soil and limestone samples. A study is also made of the availability of organic nitrogen in commercial fertilizers.

The work of the animal-husbandry department is all conducted as research under the Adams fund. The official records of advanced registry are now maintained by the extension department.

The forestry department is conducting studies on natural reproduction in the forests at Burlington and several other places. In these localities portions of the forests are cut out, thus giving different amounts of light, and all of the young trees are carefully marked in each plat. One plat received lime. Data on temperature, rainfall, soil moisture, and climatic conditions are carefully kept. In each case one or more experimental plats have been established together with corresponding check plats. The plats are 100 feet square with isolation strips surrounding them. The study of hardwoods was continued for the purpose of determining a more efficient and accurate method of estimating old growth of hardwoods, especially in culled stands. The available volume tables appeared to give unsatisfactory results. Data were obtained for 300 trees of beech, birch, and maple. Some attention is also being given to the study of eccentric growths in trees. The proliferation of cells produced by bending young trees appears not to be due to mechanical causes, but to gravity which affects the movement of the sap.

The department of plant pathology made a study of the effect of digestive fluids of animals on the viability of spores, particularly of oat, corn, and barley smut. Additional data were also secured as to resistance of several varieties of cabbage to club-root and as to the effects of soil treatment upon the prevalence of this disease. The red rot of conifers, caused by *Trametes pini*, was carefully investigated. This fungus attacks tamarack, pine, hemlock, spruce, and balsam. Infection occurs mainly through broken branches. It was found that prevention was best effected by proper thinnings and removing diseased trees and destroying fruiting bodies.

The horticultural department was studying the problem of controlling the quality of Hubbard squash by seed selection. Strains of high-yielding and low-yielding squashes have been developed. An effort has been made to learn the extent to which self-fertilization was practical. About 2 acres were devoted to this work. Data will be collected on the extent to which high yield and low yield are hereditary. The possibility of improving strawberry plants by stolon selection on the basis of parental yields is being studied.

In this work earliness and lateness, stolons from 1-year-old and 2-year-old plants, high and low yields, and abundance and scarcity of stolons are the contrasting factors. The study of the effect of selecting scions from parent trees of superior or inferior fruiting habits was also continued. Many of the scions are coming to a bearing age and data will then be obtained of the results of this experiment.

The veterinary department continued its work on infectious abortion. Samples of blood from more than 500 cows were subjected to the complement fixation test and 100 reacting cows were treated with methylene blue and cresol. The period of treatment had been reduced to three weeks. Some improvements were made in the technique of the complement fixation test. On account of the high price of methylene blue, a mixture containing 1 part of cresol and 2 parts of methylene blue was used with quite satisfactory results. About 5 per cent of the treated and 30 per cent of the untreated animals aborted. Incidentally it has been found that blood serum can be preserved on strips of paper for three years. Reliable reactions are obtained after that time. It is therefore not necessary to test the blood immediately, but samples may be preserved for more convenient examination.

The inspection work of the station, as heretofore, involved an examination of the commercial feeding stuffs, commercial fertilizers, and agricultural seed. Bulletins containing the tabulated results of these examinations were published.

The following publications were received from this station during the year: Bulletins 189, Commercial Feeding Stuffs—Concerning the Corn Crop; 190, Commercial Fertilizers—Crop Rotation; 191, The Red Rot of Conifers; and 192, Agricultural Seed.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	1,000.00
Fees	2,568.21
Miscellaneous	2,127.50
 Total	 35,695.71

While the Vermont station receives no direct State appropriation except an allowance for printing, a more liberal arrangement on the part of the university with reference to overhead expenses and expenses connected with farm operations has considerably relieved the station. A large amount of good work is being conducted in a scientific manner, and the station is a force in the State.

VIRGINIA.

Virginia Agricultural Experiment Station, Blacksburg.

W. J. SCHOENE, M. S., *Acting Director.*

The Virginia station passed a satisfactory and successful year. Dr. A. W. Drinkard was appointed director, to assume his duties on July 1, 1916, after which W. J. Schoene, who had been acting director, gave his entire attention to the office of State entomologist and plant pathologist of which he has charge. The total area now used by the experiment station for experimental purposes in Blacksburg is 130 acres. There are nine substations in Virginia, and Adams work is also carried on at Crozet, where an orchard of 33 acres is maintained for the investigation of fruit-bud formation. Six of the substations are maintained by a State appropriation of \$16,000 annually made for the investigation of tobacco and field crops. A surplus fund received from the fertilizer tax amounting to about \$7,500 a year is used to support the other three substations. The beef-feeding work and experiments with dust insecticides attracted particular attention among farmers during the year.

Adams fund work.—The study of the effect of soil environment upon the formation of fruit buds has been in progress since 1911. All treatments used in this study are duplicated at Blacksburg and Crozet. Soil moisture and plant food are the main factors under investigation. The orchards are arranged in three divisions, one maintained at a high percentage of moisture by means of cultivation and irrigation if necessary, the second being maintained in accordance with the average system of commercial culture, while the third is kept in sod. The soil moisture in the first division is kept at about 20 per cent. Numerous observations by way of growth measurement are made on each individual tree. The best yields thus far have been obtained from the division under high moisture. Both apples and peaches are used in this experiment. It has been found that spring pruning has a tendency to lessen the formation of fruit buds, while fall pruning did not materially influence the crop or buds. Severe root pruning when accompanied by spring pruning of the branches stimulated to some extent the formation of fruit buds.

In continuing the project on apple breeding, further progress was made in developing a strain of late blooming apples. A large number of cross-bred seedlings of late blooming varieties were fertilized by pollen from standard varieties. Some difficulty was experienced by reason of the poor germinating power of hybrid seeds. In a few cases nearly all the seed from a given cross failed to germinate. In

this work a number of standard varieties have been crossed on each of two dwarf varieties of apples.

The investigation of the fixation of phosphoric acid by soils was actively continued. Some soils were found on which no growth took place unless phosphoric acid was added. Sodium phosphate, acid phosphate, and slag have given the best results, their effectiveness being proportionate to their solubility. The soils used in this experiment were found to fix 95 per cent of the phosphoric acid which was applied. Phosphoric acid seems, however, to be fixed only toward solvents, but not toward plants, as is shown by its residual effect. Iron and aluminum phosphates proved to be fairly available for plant growth. No evidence has been obtained of acidity in soils due to the continued use of acid phosphate. This work is carried on in soil cylinders and in plats with continuous corn culture.

Some interesting results were developed in the study of the effect of green manuring upon the soil. A large increase in nitrates and of bacterial counts was noted as the result of green manuring. When cellulose was used in the place of green manure the plants turned yellow, nitrate formation ceased, and the bacterial count was greatly reduced. Similar results were obtained in plats containing a nutrient solution. Green manuring increased the yield to the extent of 10 bushels per acre in the case of corn and to a similar extent with wheat. In the numerous soil samples taken for bacteriological examination, an increase in the number of bacteria in the field under green manuring was definitely shown in every case.

Work on the determination of the protein and energy requirements for milk production progressed actively. The energy requirements thus far determined agreed very closely with those reported by Dr. Armsby. One group of cows received, in addition to a basal ration, black albumin, while another received starch. Apparently black albumin increased the digestibility of the rest of the ration, while starch has no such effect. Black albumin also appears to increase the percentage of fat in the milk and the total protein required per pound of milk. In this work the calves will be maintained under the same condition as the cows. Attention is also being given to the physiological effects of rations.

The principles governing the growth and maturity of corn received active attention during the year. No relation was found between the quickness of germination of the seed corn and the earliness of maturity. It was found, however, that flint corn in general germinates more quickly than dent corn and also matures earlier. Within the types of dent or flint corns, however, the relation appeared to be obscure. Careful attention was given to selection within pure lines

in order to obviate the difficulty of individual variation. Evidence was obtained that the optimum moisture content of corn is 70 per cent of saturation. The maturity of corn was retarded three or four days by excessive watering after tasseling. Abundant water before tasseling decidedly increased the yield. Incidentally it was found that large kernels germinate the most quickly.

The project on the relation of the parasitic fungi and bacteria to their host plants was carried forward actively. Attention was given to investigation of the factors which influence infection, particularly light, temperature, and water, chiefly with reference to apple rust. In studying the relation of humidity to the spread of apple rust a special spore trap was devised to show the rate of dispersal of rust spores. It was found that a rainfall of four hours or more is necessary to cause the discharge of spores from the cedar galls. Following a rainfall of such length the spores are discharged for a period of one hour or less. Meteorological factors in relation to the infection of apple rust were studied, particularly at White Post, Va.

In the study of soil bacteria, attention was given chiefly to the nitrification of blood meal, casein, urea, and peptones in the three types of soil. The work was carried on under both aerobic and anaerobic conditions before and after sterilization of soils. Ammonification in soils and in solutions was higher under anaerobic conditions, especially with urea. An organism was isolated which caused more active ammonification under anaerobic conditions. In general ammonification was found to be about as rapid under aerobic as under anaerobic conditions.

Work with Hatch and other funds.—The horticultural department carried on quite a wide range of experiments in breeding truck crops and ornamentals. In the case of lupines it was found that blue color was dominant to red and that red in turn was dominant to white. Mendelian principles appeared to govern the color in phlox. The orchard in which variety work was carried on is mostly planted to apple trees which were used in part in spraying experiments for brown rot, scab, curculio, and other insect and fungus diseases. A cheap and effective contrivance for sizing and grading peaches and apples was devised. As a substitute for self-boiled lime and sulphur, excellent results were obtained from a mixture made of hydrated lime and sulphur according to the formula 8 pounds commercial ground sulphur and 5 pounds hydrated lime in 8 gallons of boiling water. Variety tests were also carried on with bush fruits and grapes at Winchester, Crozet, and Cloverdale and fertilizer and grafting experiments with apples.

The work of the chemical department was largely concerned with the prosecution of its Adams fund projects. Some additional work of a miscellaneous nature was performed, including a study of the proper time to cut silage corn, and miscellaneous analyses in cooperation with other departments. In a study of the solubility of arsenic when lead arsenate is added to different spray solutions, it was found that potassium sulphids dissolve more arsenic when mixed with lead arsenate than the commercial lime and barium sulphur spray solutions. When lead arsenate was added to the different sulphur spray solutions the amount of arsenic in solution was increased, thus accounting for the burning effect of the mixture.

A considerable variety of general experiments was carried on by the agronomy department. In cereal investigations large nursery plats were maintained for the selection of superior strains. Variety tests were also conducted with wheat, rye, barley, and oats. Certain strains were found which possessed superior yielding powers. Experiments were also under way with corn and also experiments with different methods of seeding wheat. The grazing work of the station is conducted in cooperation with this department. Heavy grazing has been found beneficial for blue-grass pastures, for weeds grow too rapidly in such pastures under a system of light grazing.

The departments of plant pathology and bacteriology are conducting a plant disease survey in cooperation with this department. In cooperation with the horticultural department a study of tomato selection with reference to disease resistance is being carried on. Some attention was given to the control of tomato diseases by dusting with sulphur and by spraying with Bordeaux mixture and arsenate of lead. An apple-root rot which has recently assumed considerable importance is receiving active attention. The frog-eye leaf-spot of apples was also studied. This disease was found to be due to *Sphaeropsis malorum* which also causes a canker of the trunk and branches of apple trees. The disease may be readily controlled by applications of Bordeaux mixture.

The animal husbandry department conducted some feeding experiments with steers using silage and cottonseed meal in comparison with corn meal and stover. The silage was fed in rations of 35 to 50 pounds and the cottonseed meal in rations of 1 pound. The greatest total gain was produced by silage alone in a ration of 38 pounds per day. Steers fed on silage shed their coats earliest in the spring. The cost of 100 pounds of gain was \$7.46 on silage alone and \$12.16 on corn and stover. Another feeding experiment involved the use of cottonseed meal in rations of 1, 2, 3, and 4 pounds. The results of the experiment have not yet been tabulated. Oatmeal, blood meal, and linseed meal were used in calf rations. A mixture of oatmeal and

blood meal was found to be the cheapest calf ration as a substitute for milk. The department also carried on experiments in feeding peanut hulls and palm oil to beef cattle. In a study of ice cream, it was found that smoothness depends upon the amount and fineness of division of solids present other than those in true solution, while the keeping qualities of ice cream appear to depend upon the stability of the mixture.

The entomological work is conducted by the office of the State entomologist and plant pathologist. Most of this is inspection work. Attention is being given to the control of apple rust and chestnut-bark disease. A special effort is being made to determine more accurately the life history of the green-pea aphid near Norfolk. During the dry season this aphid lives on Lespedeza along streams. At Norfolk there appear to be several broods of potato beetles and this greatly complicates the problem of controlling this pest.

The following publications were received from this station during the year: Bulletins 209, The Frog-eye Leaf-spot of Apples; 210, A Stone-fruit Spray Made from Hydrated Lime and Sulphur; Technical Bulletins 1, The Effect of Association of Legumes and Non-legumes; 2, Notes on Plant Diseases in Virginia Observed in 1913 and 1914; 3, Nitrogen Fixation and Nitrification in Various Soil Types; 4, The Effect of Some Organic Soil Constituents upon Nitrogen Fixation by Azotobacter; 5, Some Effects of Pruning, Root Pruning, Ringing, and Stripping on the Formation of Fruit Buds on Dwarf Apple Trees; 6, The Effect of Green Manure on Soil Nitrates Under Greenhouse Conditions; 7, Smoothness and Keeping Qualities in Ice Cream as Affected by Solids; 8, The Amount of Arsenic in Solution when Lead Arsenate is Added to Different Spray Solutions; 9, The Cedar Rust Disease of Apples Caused by *Gymnosporangium juniperi-virginianæ*; and the Annual Reports for 1913 and 1914.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	14,999.75
Balance from United States appropriation, Adams fund	.25
State appropriation	23,125.00
Farm products	4,061.15
Miscellaneous	312.84
Balance from previous year	3,278.66
 Total	 69,777.65

The Virginia station is in a promising condition and is reaching out into the State through its substations. A cordial system of co-operation exists between the different departments, which are working loyally and industriously for the promotion of the agriculture of the State.

WASHINGTON.

Washington Agricultural Experiment Station, Pullman.

I. D. CARDIFF, Ph. D., *Director.*

Considerable progress was made by the station during the year in strengthening its research work and in the problems of organization. The area devoted to experimental work is about 40 acres in addition to 10 acres recently acquired for experimental purposes by the botanical department. The funds received from the State amounted to about \$18,000. The western Washington station, at Puyallup, receives \$57,000 for the biennial period, and the sales fund available to the institution brings the annual income of the substation up to about \$35,000 per year. The substation, however, is not under the supervision of the director of the main station.

Dr. E. O. Holland succeeded E. A. Bryan as president of the institution; E. Fulmer, head of the department of chemistry, was killed in a railway accident; Dr. J. W. Kalkus succeeded Dr. S. B. Nelson as station veterinarian. Dr. Nelson will hereafter devote his entire time to college duties. Dr. J. S. Caldwell was appointed in charge of investigations of fruit by-products. On account of lack of funds for the employment of research assistants some of the scientific work of the institution was considerably hampered. An effort will be made to secure sufficient State funds to provide research assistants for the heads of departments. A farm foreman's cottage and a barn were erected on the Adams County branch station at Lind and an insectary at the main station.

Adams fund projects.—The investigation of soil moisture was conducted under irrigated conditions at Ritzville and under dry-land conditions at Pullman, with particular reference to the relative moisture requirements under different methods of tillage. Special emphasis is being laid upon the relation of moisture to nitrogen supply. The work is conducted both in the field and in pot cultures, note being taken of the effect of previous crops upon moisture content. At Grandview also a study is in progress of the effect of water on alfalfa, corn, and potatoes. At Pullman it was found that nitrates and tillage vary together, their relation being extremely close. Moisture is also correlated with tillage, but less closely. It was found that wheat absorbs soil moisture down to the wilting point to a depth of 4 feet and draws upon soil moisture to some extent to a depth of 9 feet.

The study of factors controlling the metabolism of bovine tubercle bacilli was continued actively. Considerable progress was made in perfecting synthetic media for use in growing tubercle bacilli. A basis has apparently been laid for the study of fundamental phases of

metabolism of the tubercle bacillus. The artificial medium chiefly used in this work contained ammonium, potassium, and sodium phosphate, magnesium sulphate, glycerin, and distilled water.

The project on the progressive development of the wheat kernel was completed during the year. In the course of this work it was found that inorganic materials occur in high percentage in the young plants. The largest amount of potassium nitrate was found chiefly in the root and stem just before the flowering period. Free phosphate increased to a maximum during the development of the sporogenous tissue. From the period of the fertilization of the egg cell to the mature grain a stream of nutrient materials for the growing embryo comes to the endosperm from the leaves and blooms. The nitrogen compounds in the endosperm just before ripening of the grain include asparagin, arginin, histidin, and some leucin. The formation of the storage protein in wheat seems to be a condensation process taking place during the desiccation of the wheat kernel.

Further progress was made on the study of goiter in animals in the eastern Cascade counties. The disease showed a wide occurrence, affecting sheep, goats, and swine. It was found that big neck of calves and hairlessness of pigs occur quite generally in various parts of the State. Thus far, however, it can not be stated whether the cause of hairlessness in pigs and the enlargement of the thyroids is the same. The evidence indicates that the trouble is one of nutrition and that hairlessness and goiter are not necessarily associated. A few experiments in applying tincture of iodin to cows showed encouraging results.

The study of the effect of parasitism on the host insect was somewhat delayed by troubles experienced in getting a suitable parasite house. The insectary has now been completed. The work related chiefly to the parasites of the cabbage aphid, of which four common species were found, being the same as those which occur in the Eastern States. It appears that at a half-grown stage the fat tissue within the parasitized cabbage aphid begins to disappear, while just before the final larval stage of the parasite all the tissues of the host are consumed.

The results obtained in the investigation of the progressive immunity of insects to insecticides varied greatly in different localities. In Wenatchee and Clarkston scale insects proved to be unusually susceptible to the effect of lime-sulphur in contrast with the results obtained during the previous year. The work was confined entirely to San Jose scale and the insecticides in use were chiefly sulphur compounds and oils. It is planned to continue this work in the greenhouse under more accurately controlled conditions.

In continuing the project on inheritance in cereals, much attention was given to smut resistance in hybrids. The Turkey Red wheat was

found to be most resistant (about 95 per cent, as compared with a resistance of 3 to 32 per cent in other varieties). A beginning has been made in the study of the inheritance of grain color and of the spring and winter factors. When two spring wheats are crossed it appears that a portion of the offspring are winter wheats. Hybrid offspring from two and six rowed barleys split up in the Mendelian ratio.

The project on Mendelism in raspberries made satisfactory progress. Numerous crosses were produced between raspberries and blackberries, involving six species of raspberries and also loganberries. It was found that loganberries in hybridization experiments behave like true species and not like hybrids. Seedlings from self-fertilized seed resemble the parent. In many cases of hybridization between raspberries the seed are sterile. Moreover, some of the seedlings produce no pistils. About 2,000 seedlings of the second generation have been obtained and will be subjected to further study.

In the investigation of winter desiccation of fruit trees, attention was directed largely to so-called winterkilling and rosette. Thus far the evidence indicates that rosette is the chief form of the trouble. The growth of alfalfa or clover in the orchard will correct the trouble within three to five years. Rosetted wood grafted on healthy wood makes a normal growth. In some unexplained manner alkali appears to be connected with the disease. No satisfactory explanation has been obtained for the good effect of cover crops in connection with this trouble.

Interesting results were obtained in the further study of the influence of cultivation on the nitrogen content of wheat. It had been previously shown that wheat receiving 20 inches of irrigation water contained as much nitrogen as wheat which received less water. These results were verified during the year. Water appeared to be an aid to the development of a high nitrogen content. The highest average nitrogen content occurred in wheat grown upon summer fallow, while the lowest nitrogen content occurred in wheat grown on ground used for the production of wheat hay the previous year. Large differences in nitrogen content were brought about as the result of variation in cultivation. It appears that if conditions are not favorable to the transfer of other food materials from the soil the starch content will be disproportionately large. Summer fallow increased the nitrogen content of wheat while, within reasonable bounds, a variation in the amount of water had little effect on the nitrogen content.

The study of sulphur as a plant food was continued in quartz sand cultures. Without the addition of sulphur, wheat in such cultures made a very poor growth. It was found, however, that wheat appears to require less sulphur than most other crops. In this work

gypsum and flowers of sulphur were used as sources of sulphur. Apparently sulphur and nitrogen together are limiting factors in the development of green color. The project on the relation of the composition of wheat to soil types was confined to one series of experiments. In the case of spring grain it was found that the best composition of wheat is obtained on soils from the north slope, the nitrogen content being higher. On commercial farms, however, little difference was found in the composition of wheat grown on the north and south slopes. Apparently the tilth of the soil is the main factor influencing the composition of the grain.

Further study of tomato blight indicated that this disease in all instances is caused by *Rhizoctonia*. The same species of fungus appears to cause a similar disease of potatoes. The fungus occurs on 15 to 20 host plants, including beans, carrots, and peas. An attempt is being made to determine the durations of infection in the soil. The disease develops more virulently in acid soils. Incidentally, it was found that a shortage of water induces a more serious form of the trouble, and that tomato plants set deep in the soil endure attacks of the disease better than when planted shallow.

Work with Hatch and other funds.—The department of farm crops carried on a large variety of experiments. Variety tests were conducted with oats, wheat, barley, and corn. These tests are carried on in the nursery in triplicate-rod rows and duplicate tests are conducted in the field. Cultural experiments were conducted with alfalfa and various forage crops in rotation experiments. Nearly 300 varieties of spring and winter wheats were involved in variety tests. An attempt is being made to secure a pure strain of alfalfa by self-fertilization. For this purpose 90 varieties are under observation. Some attention is being given to seed production with alfalfa, red clover, and sweet clover. In the long-continued rotation experiments the value of barnyard manure has been thoroughly demonstrated. Different depths of plowing, ranging from 4 to 8 inches, gave no difference in the yield of spring wheat. Further work on dust explosions in thrashing machines confirmed the previous work of the station.

The department of botany studied the effect of sprays upon plants, the etiology of pear blight, and other minor problems, but devoted a large amount of attention to wheat smut. On account of the great prevalence of smut in the Palouse region, the disease has been studied from various standpoints. Evidence has been obtained that smut is disseminated by wind and that it may be largely controlled by either early or late planting. The explanation for this result is found in the fact that the wheat crop thus escapes the main "showers" of smut spores. In further work on fire blight of pears it was found that the disease sometimes invades the leaves. The study of fruit by-products was taken up actively, particular atten-

tion being given to the desiccation of fruit. The whole ripening process of prunes will be studied in connection with this work. In the study of apple by-products attention will be given to the chemical composition of apples, with particular reference to sugar, tannin, and acid.

The work of the department of chemistry is chiefly supported by Adams funds. The department cooperates with various other departments, however, and conducts work on a few minor projects. During the year the problems involved in the preservation of eggs by water glass were carefully studied, and interesting results were obtained. It was found that when preserved by water glass the alkalinity of the white of the eggs and the acidity of the yolk are lowered. By the addition of bicarbonate of soda the alkalinity and volume of the egg content were increased and the eggs were rendered more suitable for culinary purposes. It was found that eggs exhibit a colloidal absorption of water and become distended.

In dairy husbandry investigations were conducted as to the value of different types of silage for feeding dairy cows and different substitutes for milk in calf feeding. Moreover, the relative producing capacity of large and small cows were studied. Some experiments were also carried on in feeding dairy cows, in butter making, and in methods of constructing barns and milk houses.

The work in animal husbandry included a test of the relative feeding value of tankage and certain proprietary feeds as a protein supplement to barley for pigs. The proprietary feeds gave unsatisfactory results. Experiments were also conducted on the methods for wintering pigs and on the feeding value of wheat and barley for pigs. The results from this experiment were in favor of wheat. Some data were also gathered on the cost of proper gains in pigs fed by the self-feeder.

General breeding experiments, chiefly under dry-land conditions, were carried on at the Lind and Waterville substations. The chief projects under investigation at these stations are tests with cereals and forage crops, tillage and fertility investigations, and studies of trees and shrubs suitable for dry-land conditions.

The following publications were received from this station during the year: Bulletins 122, A Study of Grazing Conditions in the Wenaha National Forest; 123, Time and Method of Tillage on the Yield and Comparative Cost of Production of Wheat in the Palouse Region of Eastern Washington; 124, Bud Weevils and Other Bud-eating Insects of Washington; 125, Preliminary Note on Leaf Invasions by *Bacillus amylovorus*; 126, Bunt or Stinking Smut of Wheat; 127, Twenty-fifth Annual Report, 1915; 128, Forage Crops in Central Washington; 129, Oats in Washington; 130, The Dip-

terous Family Scatopsidae; 131, Evaporation of Apples; Popular Bulletins 75, The Babcock Test and Its Application; 92, Feeding Dairy Cows in Washington; 93, Rural Sanitation; 94, Contagious Abortion in Cows; 95, The Dairy Barn and Milk House, How to Construct Them; 96, Butter Making on the Farm; 97, Dairy Herd Records, Their Value, and How to Keep Them; 98, Hotbed Construction; and 102, Some Possibilities for the Utilization of Low Grade and Surplus Fruit.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	54,504.38
Individuals	2,510.01
Farm products, including balance from previous year	9,020.23
Miscellaneous	3,237.70
Total	99,272.32

The Washington station as a whole is progressing in a satisfactory manner. The research work on wheat smut, on the chemistry of wheat, and the breeding of cereals is particularly active. The station is taking hold of the various problems, especially of eastern Washington, and could make good use of funds to enable it to provide research assistants.

WEST VIRGINIA.

West Virginia Agricultural Experiment Station, *Morgantown*.

J. L. COULTER, Ph. D., *Director*.

The year was a prosperous one for the West Virginia station. Encouraging progress was made on nearly all of the important projects. The work of the station is arranged on a project basis. The station now has available nearly 700 acres of land for experimental purposes, about 20 acres being devoted to the poultry plant, 63 acres to horticulture, 85 acres to dairy husbandry, 330 acres to animal husbandry, and 108 acres to agronomy and soils. The State appropriated \$100,000 for an agricultural building, and plans have already been drawn for a building 60 by 100 feet, with a basement and three floors. Substation work was carried on in Cabell, Greenbrier, and Hardy Counties. A department of forestry was established during the year, and A. B. Brooks was appointed in charge. Dr. J. L. Coulter assumed his duties as director of the station September 1, 1915. The State legislature made a direct appropriation of \$20,000 for experiment station work. This sum will make it possible for the station materially to increase its operations.

Adams fund projects.—Management and feeding of poultry as related to vigor of germ in hens' eggs were studied actively and with

interesting results. A physical examination of eggs indicated that the larger the egg the smaller the yolk percentage of the whole egg. When eggs are laid in cycles it appears that the first egg in the cycle is usually heaviest. Rations with a large amount of animal protein appear to weaken the vitellin membrane. Eggs from fowls fed wheat were somewhat heavier than those from corn-fed fowls. The chemical studies with reference to the amount of carbon dioxid given off during incubation were continued. Evidence was obtained that for best results the top of the egg should be kept warmer than the lower portion. An incubator has been designed for furnishing these conditions.

The project on correlation between lime requirements of soils and their bacterial activities was continued actively. For the production of a good crop of soy beans it was found necessary to satisfy the lime requirement of soil by the Veitch method. Small applications of lime on acid soils appear to be more economical than large ones. Plants which are able to utilize ammonia nitrogen can be supplied with nitrogen on acid soils without the use of lime. It appears that nitrogen fixation takes place readily in Ashby's solution with acid soils, having a lime requirement as high as 4,600 pounds. Nitrogen fixation by soy beans takes place satisfactorily in soils with a lime requirement of 3,500 pounds. It is believed possible to devise a system of agriculture in which the nitrogen supply can be maintained and satisfactory crops produced without the use of lime.

Some difficulties were experienced in prosecuting the project on apple pollination. Many of the blooms which had been carefully hand-pollinated failed to set for some unknown reason. During the year a bibliography of pollination work was secured and a partial review of important publications was made. A study was made of the development of pollen tubes of Rome Beauty apple, a largely self-sterile variety. Some attention was given also to the influence of bees in increasing the fertility. It was found that the presence of a Ben Davis tree in a Rome Beauty orchard increases the set of fruit.

The physiological effect of pruning apple trees was studied actively during the year. Five years' work on this project has now been tabulated, indicating the effects of various types of pruning on vigor of growth and on production. Some additional analyses will be made to determine more accurately the effect of pruning on foliage, plant food, and related phenomena. Pruning experiments have been conducted on apples and peaches, but supplementary work under the support of State funds will be done on cherries, plums, and quinces. Thus far the work has shown that heavy pruning during the dormant period does not necessarily give a heavy growth. The yield was not

increased by summer pruning. On the contrary, it was diminished, especially in young trees where the practice seemed greatly to weaken the vitality. In further work on the cucumber mildew the fungus was retained in pure cultures and then transferred to aseptic cucumbers. Spores which were transferred from agar cultures did not germinate and other difficulties were met with in this work.

Considerable attention was devoted to the investigation of apple rust. A large mass of data has been accumulated with reference to the agency of wind in disseminating the disease. Circles of 1, 1½, and 2 mile radius have been laid out at the same altitude and the same distance from the mountains. Data also have been gathered with reference to the intensity of the infection and its correlation with meteorological conditions. Apple rust causes defoliation of York Imperial apple trees. It was shown that apple leaves have a period of susceptibility followed by a condition of immunity. Apple leaves are susceptible only when young. The disease may be controlled by spray materials but the destruction of cedar trees has been found to be the only completely effective means of control.

In continuing the study of temperature as related to insect life a series of experiments bearing on the establishment of the developmental zero was brought to a close. Some of these tests have been carried on continuously for 23 months. Particular attention was given to the influence of variable temperatures on insects. Incidentally it has been found desirable to consider also the influence of hereditary tendencies upon the relation of temperature to insect development. Fly pupae which were kept at the zero point of development for 23 months were found to develop after this period in an apparently normal way.

Delays were experienced in beginning the study of the control of insects by impregnating the sap of plants with poisonous substances, on account of the difficulty in obtaining certain chemicals. A survey of the literature of the subject has been made and all plans have been laid for active work during the coming season. Attention will also be given to a determination of the effect of poisonous chemicals upon plant juices.

The study of the effect of pressure on bacteria was largely concerned during the year with high pressures as applied to milk. The object of this investigation was to find the lowest pressure which may be relied upon to destroy pathogenic organisms and to lower the total bacterial count of milk so that it will compare favorably with pasteurized milk. The pressure required to destroy bacteria has been found to be determined by a number of factors such as type of organism, character of culture media, temperature and length of time during which pressure is applied. As a result of a large number of tests the lowest reliable pressure appeared to be some-

what higher than could be practically applied under commercial conditions. It is hoped, however, that means may be found for securing the beneficial results without quite such high pressure. It was found that a virulent form of bovine tubercle bacillus is destroyed by pressures ranging from 70,000 to 80,000 pounds per square inch.

Work with Hatch and other funds.—The work of the agronomy department covered a wide range of experiments. Variety tests with soy beans, oats, wheat, buckwheat, and corn were carried on and a comparative test was conducted to determine the relative value of the hill and row method for determining the yields of selected strains of plants. Among 35 varieties of soy beans under experiment 2 were quite remarkable for their oil content. In variety tests with oats two strains were found of pronounced superiority in yield. An experiment was conducted to determine the effect on yield of mixing pure strains of wheat. Some attention was also given to methods of pasture renovation by means of fertilizers, lime, mixed seeding, and disking. Fertilizer and variety tests of tobacco were conducted at the substation in Cabell County.

The horticultural department conducted breeding experiments with potatoes to determine the effect of bud selection. A study of the effect of thinning apples was also made. Fertilizer tests with apples and peaches confirmed the results of previous years that the effect of nitrogen was plainly evident, while that of other fertilizing materials could not be detected. No large beneficial results were secured in orchards through the use of commercial fertilizers. Other work included a test of spray nozzles, an apple-orchard survey, a comparison of certain standard varieties of apples, peaches, plums, cherries, apricots, bush fruits, and strawberries, and varietal and cultural tests with grapes.

The entomological department studied methods of controlling woolly aphis and peach-tree borer and compared dusting and spraying methods for the control of insects. Experiments on the peach-tree borer indicated that miscible oils sprayed on the bases of the trees in the fall will satisfactorily control this pest. The oils must be thoroughly applied from the base of the tree up to a height of 6 or 8 inches above the general surface of the soil.

The work of the animal-husbandry department comprised a live-stock survey, experiments in growing and feeding beef cattle, breeding milking Shorthorns and young sows, and feeding hogs on limited grain rations. The experiment in growing beef cattle involved the use of 30 cows and 30 yearling steers and was conducted in cooperation with this department. A beginning has also been made in an experiment to ascertain the most satisfactory ration for wintering beef cattle. Other work included a study of the cost of milk production

and of the effect of the official testing of pure-bred cows on the improvement in milk yield.

The poultry department devoted its efforts chiefly to the use of green feed for winter egg production, the eradication of gapeworms, the distribution of pure-bred stock, and selection of fowls for vigor. No definite results were obtained from the use of green feed as regards winter and spring egg production, but green feed quite decidedly increased the hatchability of eggs laid in April and May.

The soils department summarized the results of 15 years' work on the series of fertility plats. These plats were further studied with regard to the residual effect of fertilizers. In general it appeared that barnyard manure has a fertilizing value of about \$3 a ton. Acid phosphate appeared to have a high fertilizer value for all of the plats. During the series of experiments conducted on these plats it appeared that the increase in crop due to the expenditure of \$1 for acid phosphate had a value of \$9.14.

The chemical department devoted considerable attention to the improvement of analytical methods and laboratory equipment. A large amount of analytical work was performed for other departments of the station and for farmers and for the State geological survey. The fertilizer-control work has reached larger proportions than ever before and naturally occupies much of the time of the chemical department. Some improvement was made in blast lamps and in the equipment for the determination of moisture, fat, and fiber in feeding stuffs.

The work of the department of plant pathology included a study of leaf spot and late blight of tomatoes, both of which diseases were found to be controllable by spraying and dusting. Laboratory studies were made to determine the method of infection and the life history of the organisms. Some attention was also given to various apple-leaf diseases under West Virginia conditions. Spraying and dusting tests were conducted with apples and peaches in commercial orchards. Further attention was also given to onion diseases.

The department of farm management carried on agricultural-survey work in several counties. In this work special attention is devoted to labor incomes, the cost of production of the principal farm crops, and a social and economic study of communities.

The new forestry department inaugurated experiments to test the economic value of locust planting in West Virginia pastures. Attention will be given to the production and effect of root nodules and of the growth of locust trees on grass and other forage crops. A survey was also begun of the forest trees of the State, during which attention will be given to chestnut blight.

The following publications were received from this station during the year: Bulletins 149, Small Fruits for Home and Commercial

Planting; 150, The Fertilization of Peach Orchards; 151, An Apple Orchard Survey of Berkeley County; 153, An Agricultural Survey of Brooke County; 154, Apple Rust; 155, Experiments with Fertilizers; Inspection Bulletin 4, Commercial Fertilizers—Inspection 1915; Circulars 21, List of Bulletins Available for General Distribution; and 22, Poultry on the Farm.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	20,000.00
Fees	17,014.31
Farm products	6,495.95
Miscellaneous	155.89
Balance from previous year	53.40
 Total	73,719.55

The work of the West Virginia station is carefully organized and the funds are economically administered. The research work, particularly in horticulture, plant pathology, and entomology, is of high grade and is achieving interesting results.

WISCONSIN.

Agricultural Experiment Station of the University of Wisconsin, Madison.

H. L. RUSSELL, Ph. D., *Director.*

Much attention has been given to the organization of the Wisconsin station and with satisfactory results. In this work F. B. Morrison, who was appointed assistant director, has taken an active part. The branch stations have been placed on a separate fund and receive \$18,500 annually, in addition to \$3,500 for new construction. At Madison the experiment station has control of about 900 acres of land for experimental purposes. H. F. Wilson, of the Oregon station, was appointed entomologist.

For the most part a satisfactory adjustment has been reached in the separation of station and extension work. Some of the men are gradually developing more exclusively into extension work and others into research. At the last session of the legislature the annual appropriation for station publications was reduced from \$17,000 to \$10,000. An addition was made to the hog-cholera serum plant and a cement silo was erected for use in feeding experiments. The department of experimental breeding occupied its new barn, which has been expressly designed for experimental purposes. The barn contains accommodations for 20 cattle and has a floor space 36 by 63 feet.

Adams fund projects.—The two nutrition projects were carried on in close connection with each other. In a study of the mineral con-

stituents of feeding stuffs it was found that wheat and oat straw are quite inadequate as a ration and that additions of ash do not help out, especially in the matter of the production of healthy offspring. An actual toxicity of low degree was demonstrated in wheat. This toxicity appears to reside in the wheat oil. Much attention was given to nerve degeneration in connection with the nutrition studies. In this work it was learned that with a large mass of wheat in the ration of swine toxic effects will follow even in the presence of all the recognized factors for growth. The toxicity manifests itself in important histological changes in the nervous system not unlike those of beriberi. No one important factor for growth, such as better proteins, salts, or the fat soluble accessory body, appears able to act as a complete corrective for this toxicity. Excellent materials supplementary to grains, even in the presence of the toxicity of wheat products, have been found in alfalfa, commercial meat scraps, and buttermilk. Apparently pigs can not be grown on grains and salts alone, but must have some roughage. Poor growth in animals is considered as due to toxicity of a ration, poor proteins, poor salt mixtures, or absence of the necessary accessory bodies. It was demonstrated that hairless pigs may be produced at will by the use of deficient rations. An attempt is being made to determine the chemical nature of the accessory bodies so necessary to proper growth. Pasteurization destroys water-soluble accessory B, but not the fat-soluble accessory A. Incidentally it was learned that wheat protein may be supplemented by gelatin while corn protein is not thereby supplemented.

The influence of soil treatment on its phosphorus content was studied with particular reference to the availability of phosphates. Iron, aluminum, tricalcium, manganese, acid, and magnesium phosphates were studied in quartz-sand cultures with oats, corn, barley, rape, buckwheat, and several other crops. It was shown that plants which contain relatively large amounts of calcium feed strongly on rock phosphates. Cruciferae, legumes, and tobacco are prominent in this list. Much attention was given to the study of soil acidity and a new apparatus was devised for the determination of soil carbonates and also methods for the determination of soil acidity. It was shown that the strength of soil acids is of more importance than quantity in effect on crops. The total acidity appears to be no index to the actual lime requirement. A high strength or avidity of the soil acids makes a large lime application necessary.

A study of continued inbreeding in poultry yielded some interesting results. In this work it was decided to choose arbitrarily a character which had no particular relation to the vigor of the fowl. Fowls were therefore selected for color without regard to any other character. This work has been in progress since 1913. Inbred fowls

show a decrease in egg production and in the hatchability of the eggs. Check strains of fowls show no such falling off in egg yield. The work as a whole seems to show rather clearly a specific weakening effect of inbreeding.

In continuing the study of inheritance of factors in milk and meat production, crosses were made between Jersey and Angus cattle. Weights and measurements are taken in great detail, and a Babcock test is made on the milk each week. After slaughter the live and dressed weights are determined and the weights of wholesale cuts are also recorded. Moreover, the physical constants of the fats are determined. So much variation has been found within both the Jersey and Angus breeds that some difficulty may be experienced in interpreting the results.

The experimental work on cheese was confined largely to a study of pasteurized milk for use in the manufacture of Cheddar cheese. With the continuous process of pasteurization, milk was heated to a temperature of 165° F. By the holding process the milk was maintained at a temperature of 145° F. for 20 minutes. The results indicated that the cheese ripened better after pasteurization of the milk by the holding process. It is intended to study the use of pasteurized milk for making brick, Swiss, and Limburger cheese.

Encouraging progress was made in the project on cabbage diseases. The study of black rot was largely confined to field observations. Work on the blackleg disease was about completed. Attention is being given now chiefly to yellows in an effort to secure an immune variety. A strikingly resistant variety has been produced and is being tested in Racine, Wis., and in Iowa. In some of the tests, commercial varieties were all affected, while the resistant variety showed an infection of only 8 to 30 per cent.

Work with Hatch and other funds.—The work of the animal-husbandry department included the use of self-feeders with pigs, protein requirements of pigs, and feeding experiments with lambs and heifers. It was found that pigs eat more on a self-feeder, and an attempt is being made to determine the relative economy of this method of feeding. Work is also in progress comparing the value of alfalfa, clover, peas, rape, and soy beans for pigs. A survey of pig-feeding experiments of the various stations is being made with reference to protein requirements. In this connection a comparative experiment is under way with tankage, middlings, and skim milk. Decidedly the best results were obtained from skim milk. The largest gains were derived from the use of buttermilk fed in the proportion of 1.5 to 2.7 pounds per pound of corn. In lamb feeding, the value of roots and corn silage was compared, with results in favor of silage. Gluten feed proved somewhat better for lambs than bran. The cost

of gains in lamb feeding were slightly higher on linseed meal than on cottonseed meal. In feeding heifers, alfalfa hay was compared with oat straw. While the gain was less on oat straw the general condition of the heifers was good.

The dairy department gave particular attention to the manufacture of butter and ice cream and to sewage disposal from creameries. Leaky butter was found to be the cause of large losses, the brine leaking out of the tub under certain conditions. A low salt content and avoidance of overworking the butter are recommended, and also that the churning temperature should be 50° to 52° F. The actual shrinkage in the weight of butter between creamery and market was found to be about one-half pound in 60 pounds. Experiments indicated that lime added to sour cream helps in producing butter which keeps better in cold storage and which is less likely to develop disagreeable odors and a so-called fishy flavor. Ice cream investigations were carried on with reference to the effects of pasteurization of cream for ice-cream making. It was found that the average bacterial count in ordinary ice cream is 15,000,000 per cubic centimeter. When milk solids were added to the cream the texture of the resulting ice cream was finer and the product held up longer. In the study of methods of paying for milk at cheese factories, the Babcock test was found to give results nearer the actual cheese-making value of the milk than any other method. It appears that by adding 0.6 to fat tests the farmer will receive a just price for his milk.

In the plant-pathology department attention was given to diseases of cereals, field crops, fruit trees, and garden crops. Three species of *Helminthosporium* were found affecting barley. The trouble may be controlled by a prolonged formalin treatment. A new bacterial disease of barley was found attacking the leaves, sheaths, and heads of the plant. The cherry shot-hole disease also received much attention. This disease is due to *Cylindrosporium*, of which 8 strains have been isolated and are being studied in inoculation experiments on 22 species of *Prunus*. The fungus apparently winters over in the dead leaves and the trouble is partly controlled by plowing under these dead and affected leaves. A field laboratory for the study of the diseases of cabbages and onions is maintained at Racine, another for the study of potato diseases at Waupaca, and one at Sturgeon Bay for the study of cherry and raspberry diseases. Further experimental work was also conducted on late blight of the potato and resistance of tobacco to the root-rot disease caused by *Thielavia vasicola*.

In the department of bacteriology a study of the nitrogen cycle and acidity in soils was carried on in cooperation with the soils department. The best yields with legumes were obtained from the use

of one-half the amount of lime required to neutralize soil acidity. Inoculation showed no effect with clover but was decidedly beneficial with alfalfa and soy beans. It was found that nitro-bacteria did not persist in active soils and that about 50 pounds of nitrogen per acre is fixed by inoculated alfalfa. An attempt is being made to determine whether alfalfa is affected by acidity or by a lack of calcium in acid soils and also whether acidity affects chiefly the bacteria or the alfalfa plant. The bacteriology of milk received much attention. In the study of tests for pasteurized milk it was found that leucocytes are not stained by methylene blue in raw milk but are stained in pasteurized milk. This gives a rapid and reliable method of detecting pasteurized milk. An attempt is being made to devise a method of making bacterial counts in milk and agar cultures on a microscopic slide 4 square centimeters in area. Some study has been made of the antiseptic properties of spices. Cloves and cinnamon seem to possess some antiseptic power.

The department of farm management is carrying on regular surveys and has records of 100 farms, in some cases for six years continuously. The Wisconsin farm contest began four years ago, a start being made in 10 counties on about 150 farms. At present 800 farmers are keeping records of farm business. In general it has been found that profits are greater on farms with alfalfa or with silos. The size of the farm appears to be of less importance than the number of animals and the yield is apparently not so important as the use to which the crops are put. The highest profit was shown on farms where 20 to 50 per cent of the money invested is operating capital.

The horticultural department conducted experiments with fertilizers for potatoes, methods of determining root hardiness of apples, tomato breeding, tobacco diseases, rhubarb forcing, and irrigation of vegetables. The fertilizer work with potatoes is a pure nutrition problem in which the plant-food needs of the potato are considered. Great differences have been observed in varieties of apples between the hardiness of the scion root and stock root. A planting of 2,000 root grafts was made at different depths to study root development from the scion and stock. Some varieties have shown a strong tendency to develop scion roots. In tomato breeding an attempt is being made to develop a forcing tomato immune to mosaic disease. Some attention has also been given to lawn-grass combinations, propagation of ornamentals, and the use of dynamite in planting trees. The relation of the time of blossoming of apples to spraying is under investigation. *Thielavia vasicola*, the fungus which causes root rot of tobacco, has been found to occur quite commonly on various cultivated legumes but is most serious on tobacco and violets. A study of rhubarb forcing was carried on with the use of 1, 2, 3, 4, and 5 year-

old roots. The two-year-old roots gave the best results and showed most economy of production.

The agronomy department devoted its energies largely to the study of the hemp industry, corn and cereal breeding, soy beans, alfalfa, fertilizers, rotation experiments, and weed eradication. A special hemp break has been devised with a capacity of 1 ton of fiber per hour. As a result of extensive corn and cereal breeding and selection carried on for many years, the station is now able by means of the distribution of its pedigreed seed to determine largely the kind and quality of cereals which are grown in the State. It was shown that inoculation is quite necessary for soy beans. Little evidence was obtained of beneficial effects of commercial fertilizers. Acid phosphate applied at the rate of 300 pounds per acre increased the percentage of high-grade seed corn. Experiments indicated that Canada thistle and quack grass may be destroyed by repeated tilling and that hemp is beneficial in cleaning fields of weeds.

The entomological department gave attention to the life history of the pea aphis. The most important aphis on apple and plum appears to be *Aphis avenæ*. This species leaves the trees in June, migrating to oats. Some work was also done with codling moth, on the relation of insects to diseases of cucumber, and in bee breeding. Three applications of arsenical insecticides made in the calyx, 10 days later, and about July 25, were found sufficient to control the codling moth.

The work in agricultural economics involved a study of marketing Wisconsin butter, market milk in relation to problems of topography, cost of production and distribution of profits, and a general investigation of cooperative activities. It appears that the dairy cow is the dominant agricultural factor of the State. In the line of rural sociology, a survey of Dane County is in progress in which an analysis is made of the social life of each farm family with reference to religious, political, and race groups.

The soils department studied methods of applying barnyard manure, the comparative beneficial effects of rock phosphate and lime, and a comparison of the grain and live-stock systems of farming. Attention was also given to methods of drainage and tillage. With barnyard manure the chief questions considered were whether it should be applied as a top-dressing or plowed under and to which crop in a rotation it should be added.

The general work in experimental breeding was concerned with a study of the inheritance of color in pigeons, the physiology of egg production, selection of soy beans, and the resistance of alfalfa to soil acidity. Starting with the fact that the pigeon normally lays two eggs and then stops laying in order to incubate the eggs, an experiment was tried in which the eggs of pigeons and also of

wrens, which were captured for comparison, were removed as fast as they were laid. One wren laid 30 eggs in 45 days. Less conspicuous success was had with pigeons. No success was achieved as the result of four years' selection of pure lines of soy beans in increasing the oil content. This method of breeding is believed to offer no hope of success. In connection with the study of Azotobacter, which develops a black pigment, it was incidentally discovered that an extract from white feathers of White Leghorns would inhibit the development of black color from the Azotobacter.

The poultry experiments of the year were confined largely to a restricted grain ration for young chicks and to the effect of withholding the lime supply from hens. It was found that at the age of 6 weeks chicks which had received corn, clover, and milk weighed nearly three times as much as chicks which had received corn and clover or wheat and clover. In all feeding experiments with young chicks, milk either fresh or as buttermilk has been found to be necessary for the best growth. When the lime supply was withheld from hens or greatly reduced the number of eggs was correspondingly reduced, but the shells were no thinner than under normal conditions.

The following publications were received from this station during the year: Bulletins 253, Some Facts About Concentrated Feeds; 254, State Seed Inspection and Weed Control, 1914; 255, Facts About Fertilizers Licensed for Sale in Wisconsin; Reports of Analyses for 1914; 256, The Marketing of Wisconsin Potatoes; 257, Apple Rust and Its Control in Wisconsin; 258, Distribution of Public-service Stallions; 259, Alfalfa Growing in Wisconsin; 260, First Aid to the Settler; 261, Poultry Raising in Wisconsin; 262, Ice Cream Making; 263, Sheep Raising in Wisconsin; 264, Beekeeping in Wisconsin; 265, Commercial Fertilizers—What They Contain and Their Uses; 266, Barns for Wisconsin Dairy Farms; 267, Facts for the Feed Buyer; 268, Work Done by the Experiment Station in 1915—Director's Annual Report; Research Bulletins 35, The Comparative Effect of Phosphates and Sulphates on Soil Bacteria; 36, Acidosis in Omnivora and Herbivora and Its Relation to Protein Storage; 37, Germination and Infection with the Fungus of the Late Blight of Potato (*Phytophthora infestans*); and 38, The Control of Cabbage Yellows Through Disease Resistance.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	\$15,000.00
United States appropriation, Adams Act	15,000.00
State appropriation	98,750.00
Fees	9,812.00
Total	138,562.00

The Wisconsin station has given serious attention to the efficiency of organization with particular reference to economy in the use of funds. The relations of the members of the station staff are excellent, and the station as a whole seems to be in position to render larger and larger service to the agriculture of the State.

WYOMING.

Wyoming Agricultural Experiment Station, Laramie.

H. G. KNIGHT, A. M., *Director*.

The work of the Wyoming station moved forward in a satisfactory manner. The director was absent for nine months, doing graduate work in the University of Illinois. During this time the president of the university had charge of the station as acting director. Dr. E. H. Lehnert was appointed veterinarian. Dr. S. K. Loy, head of the department of chemistry, was relieved of station work, and the director assumed charge of station chemistry. A special laboratory was fitted up for use in research work with cements, and funds were secured for the better equipment of the laboratory devoted to general research in chemistry. The State appropriation for work on alkali land and breeding stock was \$3,000 and for laboratory equipment \$1,000. On the basis of the present half-mill tax, the University of Wyoming is expected to receive about \$6,000 additional each year, as the result of a natural increase of taxable property.

Adams fund projects.—A room specially equipped for the control of moisture and temperature enabled the station to continue its wool investigations with greater refinement of technique. Several thousand fibers were tested under conditions of controlled temperature and humidity. The results indicate that there is a point between the water-free and completely saturated state of wool fiber at which it is at its maximum strength, with a marked decrease of strength on either side of this point. The natural yolk in wool was found to be more hygroscopic than the fiber itself, while sand and other earth materials adhering to the fleece are naturally less hygroscopic than either the yolk or fiber. The cleaner the wool the more sensitive the wool fiber to moisture changes. While still covered with the film of the natural wool grease, the fiber neither absorbs nor gives up moisture readily.

The further study of woody aster indicated the presence of a glucosid, but the active principle has not yet been identified. No alkaloid has been found in the plant. An apparatus was devised for collecting the gases which are generated spontaneously when a quantity of the dried plant is confined in a closed space with water. The gas proved to be nothing but carbon dioxid. Experiments have shown that the toxic principle is largely soluble in water. An alkaloid was isolated from *Delphinium geyeri*, but it has not yet been

definitely identified. The resins and sugars occurring in this plant were quite carefully studied. A small quantity of methane gas was obtained from pulverized samples of the plants. Apparently *D. geyeri* is not poisonous during the latter part of the summer.

Further study of the toxic principle of the tall larkspur showed that this plant contains a complex water-soluble alkaloid which readily splits into two, one of which is very poisonous. One-fifth of a grain given intravenously killed rabbits quickly. The other fraction of the alkaloid is much slower in its action. Feeding experiments with water extracts, taken from the early stages of growth of the tall larkspur, show that in the early stages it is about seven times more toxic than at later periods. The alkaloids in the young plants were found to be crystalline, while those of the mature plants were amorphous. The original water-soluble poison present in the early stages of growth is a complex alkaloid. As the season advances the alkaloid becomes less soluble in water. Most of the alkaloid is found in the leaves. A study of *D. glaucescens* indicated the presence of three crystalline alkaloids in contrast with the amorphous alkaloid obtained from the mature plant of *D. glaucum*. The variation in the water solubility of these alkaloids is believed in part to cause a difference in toxicity of the two plants.

The investigation of the poisonous properties of lupines has been confined to *Lupinus leucophyllus* and an unidentified species. The resin has been separated from the plants by various methods and an alkaloid has been isolated in a crystalline form. Material has been collected in the flowering stage two weeks later with partly developed pods and at a third stage when the pods are ripe. A study will be made of the development of the alkaloid at different stages in the growth of the seed. Water extracts of lupines appear not to be toxic.

Interesting results were obtained in the further study of the transmission of swamp fever. Not only was definite experimental evidence obtained of the transmission of the disease by biting flies, such as the stable fly, but negative results were obtained from similar experiments with mosquitoes. When horses affected with the disease were kept in a screened cage together with unaffected horses where the stable fly was present, the disease was transmitted to the unaffected horses. Close association of diseased and healthy horses without the presence of stable flies showed no transmission of the disease. Attention will also be given to the possible agency of *Tabanus striatus* and a species of Chrysops as carriers of this disease. It has been suspected that the bloody nasal secretions may possibly be virulent. This matter will also receive attention.

In the project on *Tænia expansa*, feeding experiments were conducted to learn the means by which this tapeworm was transmitted.

All tests resulted negatively. The tapeworm appears to be no longer found in the range sheep of the State. Apparently transmission requires an alternate host, but this point has not yet been determined. The life cycle of *Thysanosomum actiniooides* was studied with interesting results. This tapeworm was found in 65 per cent of the range sheep of the State. Lambs do not become infected on dry lot or dry pasture. They undergo infection, however, when running in wet pastures with infected ewes. Numerous feeding experiments with ripe proglottids, as well as with various grasses and forage plants from infested pastures, gave entirely negative results.

The further study of the life history of *Sarcocystis tenella* indicated that the sheep is not the definitive host of this parasite but merely an accidental host. It was shown that lambs may become infected with sarcocysts by eating grass or by eating certain kinds of insects, particularly moths, butterflies, and their larvae. Infection was not brought about, however, by drinking water infected with sarcocystis from diseased heart muscles. The discovery that sarcocystis spends a portion of its life in certain insects is believed to harmonize with other facts concerning the life history of protozoan parasites.

In continuing the investigation of methods of proofing cement materials against alkali, experiments indicated that the various advertised resistant cements are not satisfactory. Numerous tests for tensile strengths of cements in different alkali solutions were made. A slow and gradual decrease of strength was determined by means of these tests. A method has been devised which renders cement decidedly resistant to cold mineral acids. Cement thus treated sets rather slowly, but it is hoped that this disadvantage may be overcome. Further experiments will be required before the method can be definitely announced as effective.

On account of changes in the personnel of the veterinary department, work on contagious abortion was interrupted. Plans have been made for investigating several methods of treatment, serum prevention, methods of diagnosis, and pathological lesions developed during the course of this disease.

Work with Hatch and other funds.—The agronomy department carried on a wide range of experiments. Commercial fertilizers showed no beneficial results on the station grounds, but largely increased yields followed the use of green manure and barnyard manure. Nitrogen appeared to be the limiting factor in the growth of barley, oats, and wheat. Potato blight, which has been extremely serious since 1911, caused the least injury on loose sandy soil. Irrigation experiments with cereals and potatoes were carried on in cooperation with this department. It was found that as the humus

content of the soils increased the water requirement was reduced. Variety testing was carried on with small grains. From these tests, six promising varieties of barley have been selected. In variety experiments with alfalfa, Grimm alfalfa proved to be decidedly the best for Wyoming conditions. In cultural experiments with wheat it was found that winter wheat yields best when planted not later than July 15. A study is also being made of grass mixtures for permanent pastures and meadows. A series of rotation plats was inaugurated during the year. Experiments are also in progress with sweet clover as a green-manuring plant.

The department of animal husbandry cooperated with the botanical department in a study of changes in range flora under varying meteorological conditions. Experiments were also carried on in sheep feeding, breeding Polled Herefords, the use of silage for lambs and steers, maintenance rations for steers and sheep, and fattening rations for swine. A comparison of cottonseed meal with other grains for beef cattle gave indecisive results, sometimes in favor of cottonseed meal and at other times favorable to other grain mixtures. Pea pastures gave excellent results in fattening pigs. Gains during the finishing period seemed to be more rapid in pigs which had been maintained on pasture. Approximately the same gains were made by cross-bred and pure-bred pigs. In cattle-feeding experiments, the addition of oat and pea silage to native hay produced much heavier and cheaper gains than did native hay alone. It appeared that 20 pounds of silage was of greater feeding value than 10 pounds of native hay. In sheep-feeding experiments, the most rapid gains were produced on corn and alfalfa, but oat and pea silage gave satisfactory results for breeding ewes.

The chemistry department devoted considerable attention to a study of *Astragalus bisulcatus*. Experiments with this plant showed that it is extremely poisonous to cattle. The active principle was found to be soluble in water. It is proposed to organize an Adams fund project for the further technical investigation of this plant. The chemical department also cooperates with the other departments of the station in their general investigations.

Detailed observations were made for three successive growing seasons on range land to learn the vegetative succession and change of flora which occur under the influence of irrigation. During this period of three years an almost complete change of flora was gradually brought about. The upland species disappeared and species suitable to meadow conditions took their place. Evidence was obtained that the irrigation of natural range land may furnish a cheap means of establishing satisfactory meadows.

The publications received from this station during the year were as follows: Bulletins 106, Cottonseed Cake v. Cold Pressed Cotton-

seed Cake for Beef Cows; Mixed Grains *v.* Cottonseed Cake for Growing Beef Cattle; 107, Swine Feeding; 108, Cattle Feeding; 109, Sheep Feeding, I, II, and II; and the Annual Report for 1915.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act-----	\$15,000.00
United States appropriation, Adams Act-----	15,000.00
Farm products, including balance from previous year-----	3,603.17
Total-----	33,603.17

The Wyoming station is doing a high grade of work, and the quantity of its work is relatively large for the funds which are available. The organization of the station is excellent, and it is based on a satisfactory working plan. With a State appropriation for substations the work of the station and the members of the staff would be brought into more direct connection with the live stock and other important agricultural interests in the State.

STATISTICS OF THE AGRICULTURAL EXPERIMENT STATIONS.

The total income of the experiment stations, including the insular stations, during the fiscal year ended June 30, 1916, was \$5,334,073.90. Of this amount \$720,000 was derived under the Hatch Act, \$719,999.75 under the Adams Act, \$119,978.34 from Federal appropriations for the insular stations, \$2,303,824.19 from State appropriations, \$17,686.13 from individuals and communities, \$335,269.84 from fees, \$515,791.47 from the sale of products, and \$601,523.96 from miscellaneous sources.

The value of additions to the equipment of the stations was estimated as follows:

Buildings-----	\$499,345.97
Libraries-----	42,393.25
Apparatus-----	87,827.92
Farm implements-----	99,791.32
Live stock-----	230,428.07
Miscellaneous-----	59,189.52
Total-----	1,018,976.05

The stations employed 1,866 persons in the work of administration and inquiry. Of this number 933 were also members of the teaching staff of the colleges and 561 assisted in farmers' institute and other extension work. During the year the stations published 1,733 annual reports, bulletins, and circulars, aggregating 25,923 pages, and these were distributed to 1,147,309 addresses on the regular mailing list.

The detailed statistics of the stations by States are shown in the tables following.

General statistics, 1916.

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.	Number of teachers on staff.	Number of persons on staff who assist in extension work.	Publications during fiscal year 1915-16.	Number of names on mailing list.
Alabama (College), Alabama (Canabrake)	Auburn, Uniontown, Slatka	J. F. Dugger, L. H. Moore, G. W. Carver, C. C. Georgeson, R. H. Forbes,	Feb. 7, 1883 Jan. 1, 1886 Feb. 15, 1897	Feb. 24, 1888 Apr. 1, 1888	39	12	14	310
Alaska					22	22	3	44
Arizona	Fayetteville	Martin Nelson	1889	1887	15	6	15	197
Arkansas	Berkeley	T. F. Hunt	1875	Mar. 1, 1883	22	16	36	11,150
California	Folsom	C. P. Gillette	1888	Feb. 28, 1888	106	88	35	40,000
Colorado	New Haven	E. H. Jenkins	Oct. 1, 1875	May 18, 1887	28	15	72	33,830
Connecticut (State)	Storrs	do.			20	12	14	494
Connecticut (Storrs)	Newark	Harry Hayward		Feb. 21, 1888	11	6	6	9,600
Delaware	Gainesville	P. H. Rols		Feb. 21, 1888	11	7	4	271
Florida	Experiments	R. J. H. DeLoach	Feb. 18, 1888	July 1, 1889	1888	15	7	10,000
Guam	Honolulu	A. C. Hartenbower			1888	8	12	220
Hawaii	Moscow	J. S. Jones		Feb. 26, 1892	1888	3	7	7,000
Idaho	Illinois	Eugene Davenport		Mar. 21, 1888	108	17	12	23,500
Indiana	Urbana	Arthur Goss		Jan. 17, 1888	64	80	40	12,500
Iowa	Lafayette	C. F. Curtiss	1885	Feb. 17, 1888	49	19	5	217
Kansas	Ames	W. M. Jordine		Feb. 8, 1888	76	35	13	242
Kentucky	Lexington	A. M. Peter I.		Sept. 1, 1885	44	22	9	12,500
Louisiana (Sugar)	New Orleans	W. H. Dodson		Apr. 1, 1886	1886	26	2	1
Louisiana (State)	Baton Rouge	C. D. Woods		May 1, 1887	1887	18	1	73
Louisiana (North)	Cahfoun	H. J. Patterson		Mar. 1, 1885	1885	20	4	3,000
Maine	Orono	W. P. Brooks		Apr. 1, 1888	1888	37	11	10,000
Maryland	College Park	R. S. Shaw		Mar. 2, 1888	1888	37	12	92
Massachusetts	Amherst	A. F. Woods		Feb. 26, 1888	1888	19	12	20,000
Michigan	East Lansing	E. R. Lloyd		Mar. 7, 1885	1885	72	27	50,299
Minnesota	University Farm	F. B. Mumford		Jan. 27, 1888	1888	20	8	50,000
Mississippi	Agricultural College	Paul Evans		Jan. 1, 1887	1887	61	1	73
Missouri (College)	Mountain Grove	F. B. Lintfield		Feb. 1, 1900	1900	13	21	10,684
Montana (Fruit)	Bozeman	E. A. Burnett		July 1, 1893	1893	30	4	15,000
Nebraska	Lincoln	S. B. Doren		Dec. 16, 1884	1884	14	1	15,750
Nevada	Reno	J. C. Kendall		Dec. 1, 1887	1887	3	4	3,500
Durham	New Brunswick	J. G. Lipman		Aug. 4, 1887	1887	17	12	60
New Jersey (State)	New Jersey (College)	do.		Mar. 10, 1880	1880	35	24	17,000
New Mexico	Agricultural College	Fabian Garcia		Apr. 26, 1888	1888	11	15	10,040
				D. C. 14, 1889	1889	84	8	5,363

New York (State)	W. H. Jordan.....	Mar. 7, 1882	Apr. 1888	38	9	44
New York (Cornell).....	A. R. Mann.....	1879	Mar. 7, 1887	54	54	92
North Carolina.....	B. W. Kilgore.....	1877	Mar. 7, 1887	45	8	11
North Dakota.....	T. P. Cooper.....	1880	Mar. 7, 1880	35	2	12
Ohio.....	C. E. Thorne.....	1882	Mar. 2, 1888	77	44	39
Oklahoma.....	W. L. Carlyle.....	1890	Dec. 25, 1890	19	18	8
Oregon.....	A. B. Cordley.....	1888	July 7, 1888	34	20	17
Pennsylvania.....	R. L. Wattis.....	1907	June 30, 1887	69	56	56
Porto Rico.....	H. P. Armsby.....					11
Rhode Island.....	D. W. May.....					762
South Carolina.....	B. L. Hartwell.....					40
South Dakota.....	I. N. Harper.....					200
Tennessee.....	I. W. Wilson.....					200
Texas.....	H. A. Morgan.....					200
Utah.....	B. Youngblood.....					200
Vermont.....	F. S. Harris.....					200
Virginia.....	J. L. Hills.....					200
Virginia (Truck).....	A. W. Drinker, Jr.....					200
Washington.....	T. C. Johnson.....					200
West Virginia.....	I. D. Cardiff.....					200
Wisconsin.....	J. L. Coulter.....					200
Wyoming.....	H. L. Russell.....					200
	H. G. Knight.....					200
Total.....				1,866	933	561
					1,733	25,923
						1,147,309

¹ Acting director.² In 1882 the State organized a station here and maintained it until June 18, 1895, when it was combined with the Hatch station at the same place.

Revenue and additions to equipment, 1915-16.

Station.	Federal.		State.	Individuals and communities.	Fees.	Sales.	Miscellaneous. ¹
	Hatch fund.	Adams fund.					
1 Alabama (College).	\$15,000.00	\$15,000.00	\$27,000.00	-----	-----	\$613.51	\$3,861.12
2 Alabama (Cane-brake).	-----	-----	-----	-----	-----	-----	-----
3 Alabama (Tuskegee).	-----	-----	-----	-----	-----	-----	-----
4 Alaska.	-----	-----	-----	-----	-----	-----	-----
5 Arizona.	15,000.00	15,000.00	38,651.06	-----	-----	8,761.74	1,528.66 588.24
6 Arkansas.	15,000.00	15,000.00	24,500.00	-----	\$944.93	3,415.49	3,195.36
7 California.	15,000.00	15,000.00	95,777.23	-----	6,748.26	35,916.33	34,902.24
8 Colorado.	15,000.00	15,000.00	19,868.00	-----	-----	9.00	17,213.53
9 Connecticut (State).	7,500.00	7,500.00	24,000.00	\$11,374.31	9,335.00	46.92	1,249.56
10 Connecticut (Storrs).	7,500.00	7,500.00	4,500.00	-----	-----	-----	9,782.71
11 Delaware.	15,000.00	15,000.00	5,000.00	-----	-----	1,893.58	-----
12 Florida.	15,000.00	15,000.00	8,250.00	-----	-----	2,977.10	2,729.26
13 Georgia.	15,000.00	15,000.00	3,503.21	-----	-----	2,511.61	226.05
14 Guam.	-----	-----	-----	-----	-----	474.54	-----
15 Hawaii.	-----	-----	3,000.00	1,095.39	-----	972.68	1,665.54
16 Idaho.	15,000.00	15,000.00	-----	-----	-----	4,180.40	773.27
17 Illinois.	15,000.00	15,000.00	195,500.00	-----	-----	38,663.89	18,139.58
18 Indiana.	15,000.00	15,000.00	91,000.00	2,706.42	69,182.51	-----	194,497.56
19 Iowa.	15,000.00	15,000.00	115,500.00	-----	-----	25,196.93	5,348.91
20 Kansas.	15,000.00	15,000.00	8,091.54	-----	23,337.85	-----	-----
21 Kentucky.	15,000.00	15,000.00	71,129.79	-----	58,390.33	56,240.55	48,043.15
22 Louisiana.	15,000.00	15,000.00	25,500.00	-----	14,000.00	4,736.63	-----
23 Maine.	15,000.00	15,000.00	17,171.47	-----	12,674.52	11,141.66	-----
24 Maryland.	15,000.00	15,000.00	15,462.61	-----	-----	8,692.83	2,532.58
25 Massachusetts.	15,000.00	15,000.00	34,750.00	-----	9,933.75	7,748.37	28,338.13
26 Michigan.	15,000.00	15,000.00	27,405.00	-----	14,545.00	-----	6,706.75
27 Minnesota.	15,000.00	15,000.00	180,505.94	-----	-----	63,366.09	1,433.45
28 Mississippi.	15,000.00	15,000.00	21,025.00	-----	376.00	12,983.09	2,050.91
29 Missouri (College).	15,000.00	15,000.00	17,281.77	-----	24,673.60	16,308.09	35,690.66
30 Missouri (Fruit).	-----	-----	-----	-----	-----	-----	-----
31 Montana.	15,000.00	15,000.00	55,947.18	-----	-----	5,575.03	-----
32 Nebraska.	15,000.00	15,000.00	29,181.80	-----	-----	-----	46,414.34
33 Nevada.	15,000.00	15,000.00	-----	-----	-----	9.40	2,547.11
34 New Hampshire.	15,000.00	15,000.00	-----	-----	-----	725.83	8,677.81
35 New Jersey (State).	-----	-----	84,900.00	-----	38,295.87	18,029.80	-----
36 New Jersey (College).	15,000.00	15,000.00	-----	-----	-----	-----	-----
37 New Mexico.	15,000.00	15,000.00	-----	-----	-----	2,851.56	5,720.63
38 New York (State).	1,500.00	1,500.00	105,681.70	-----	-----	-----	2,489.66
39 New York (Cornell).	13,500.00	13,500.00	53,324.90	-----	5,888.23	-----	-----
40 North Carolina.	15,000.00	15,000.00	89,240.51	-----	-----	5,065.39	2,000.00
41 North Dakota.	15,000.00	15,000.00	13,427.38	-----	-----	32,307.87	32,970.12
42 Ohio.	15,000.00	15,000.00	282,543.00	-----	-----	23,318.70	24,209.49
43 Oklahoma.	15,000.00	15,000.00	5,891.46	-----	-----	4,971.05	1,753.14
44 Oregon.	15,000.00	15,000.00	33,380.39	-----	-----	19,320.23	21,966.46
45 Pennsylvania.	15,000.00	15,000.00	-----	-----	17,549.47	34,413.96	790.45
46 Pennsylvania (Nutrition).	-----	-----	-----	-----	-----	-----	-----
47 Porto Rico.	-----	-----	-----	-----	-----	1,313.69	-----
48 Rhode Island.	15,000.00	15,000.00	-----	-----	-----	-----	6,664.88
49 South Carolina.	15,000.00	15,000.00	14,646.08	-----	-----	2,211.95	13.00
50 South Dakota.	15,000.00	15,000.00	13,000.00	-----	-----	2,796.59	10,809.18
51 Tennessee.	15,000.00	15,000.00	19,527.64	-----	-----	9,472.49	952.78
52 Texas.	15,000.00	15,000.00	140,582.50	-----	-----	19,170.53	2,100.30
53 Utah.	15,000.00	15,000.00	12,670.15	-----	-----	4,297.04	277.83
54 Vermont.	15,000.00	15,000.00	3,127.50	-----	2,568.21	-----	-----
55 Virginia.	15,000.00	15,000.00	23,125.00	-----	-----	4,061.15	3,391.50
56 Virginia (Truck).	-----	-----	-----	-----	-----	-----	-----
57 Washington.	15,000.00	15,000.00	54,504.38	2,510.01	-----	6,339.55	5,918.38
58 West Virginia.	15,000.00	15,000.00	20,000.00	-----	17,014.31	6,495.95	209.29
59 Wisconsin.	15,000.00	15,000.00	98,750.00	-----	9,812.00	-----	-----
60 Wyoming.	15,000.00	15,000.00	-----	-----	-----	2,712.78	890.39
Total.	720,000.00	720,000.00	2,303,824.19	17,686.13	335,269.84	515,791.47	601,523.96

¹ Including all balances except from Federal funds.² Including Federal appropriations: Alaska, \$39,978.34; Guam, \$15,000; Hawaii, \$35,000; Porto Rico, \$30,000.³ Territorial.⁴ Including balance from previous year, \$0.25.

Revenue and additions to equipment, 1915-16.

Total.	Additions to equipment.						
	Buildings.	Library.	Apparatus.	Farm implements.	Live stock.	Miscellaneous.	Total.
\$61,474.63	\$420.00	\$300.00	\$800.00	\$225.00	\$400.00	\$300.00	\$2,445.00
	25.00		89.05				114.05
2 42,986.88	2,426.01	10.00		1,568.05	70.75	241.00	4,315.81
78,001.04	305.93	14.85	2,289.39	622.87	581.21	1,659.23	5,473.48
64,055.78	1,500.00	579.12	1,679.79	478.57	1,949.24	149.04	6,335.76
203,404.08	10,000.00	2,000.00	6,000.00	3,000.00	20,000.00	5,000.00	46,000.00
67,090.53	3,266.44	233.20	554.28	3,772.61	375.00	352.00	8,553.53
61,005.79	388.89	525.04	65.81	364.99	6.60	179.03	1,530.36
29,282.71		117.39	96.17	71.01			284.57
36,893.58	142.45	719.24	1,232.43	1,172.25	30.00	121.90	3,418.27
43,956.36	2,060.73	522.42	537.22	474.13	752.50	273.96	4,620.96
36,240.87	1,000.00	159.25	395.00	180.00	62.45		1,796.70
2 15,474.54	1,025.82	87.76		108.95	81.00	8.95	1,312.48
2 41,733.61	302.43	246.30	328.86	384.57	27.25	483.08	1,772.49
34,953.67	3,563.32	47.27	1,081.62	1,593.09	723.75	166.59	7,175.64
282,303.47	19,543.49	445.38	4,243.74	6,959.56	3,056.00	1,462.65	35,710.82
387,386.49	16,387.07	2,318.62	2,553.92	6,323.95	58,410.15	2,759.26	88,752.97
176,045.84	2,573.64	1.80	947.03	1,182.91	1,724.40	1,340.86	7,770.64
137,429.39	3,060.07	340.19	4,434.31	1,212.71	17,756.09		26,803.37
263,803.82	9,000.00	800.00	1,100.00	1,300.00	370.00	1,500.00	14,070.00
74,236.63	300.00	542.00	443.68	1,050.84	2,184.08		4,520.60
70,987.65		714.75	594.16	774.91	849.98		2,933.80
56,688.02	1,189.98	158.71	1,769.53	1,784.32	808.40	99.53	5,810.47
110,770.25	876.71	1,159.28	515.00	590.43	910.11	121.26	4,172.79
78,656.75	1,406.43	580.95	947.39	1,414.38	2,244.00		6,593.15
275,305.48	18,324.20	2,427.48	1,276.08	5,544.45	4,845.10	1,778.26	34,195.57
66,435.00	2,600.00	103.01	50.50	102.50	19,658.21	746.35	23,260.57
123,954.12	5,638.00	1,535.20	648.41	1,079.63	4,230.37	971.65	14,103.26
91,522.21		614.00	330.00	1,460.00	1,400.00	900.00	4,704.00
105,596.14	230,000.00	1.40	495.98	191.50	150.00		230,838.88
32,556.51	2,000.00	167.39	750.00	262.96	728.97	343.10	4,252.42
30,403.64		136.18	739.92			565.00	1,441.10
141,225.67	1,000.00	337.51	653.80	578.91	1,078.56	2,339.91	5,988.69
30,000.00	8,600.00	159.64	372.00	926.00		250.00	9,807.64
38,572.19	45.77	63.43	236.13	856.08	12.00	1,428.74	2,642.15
111,171.36			3,681.34	678.90		2,254.02	6,614.26
86,213.13		5,467.00	16,799.00	6,229.00	6,025.00	5,854.00	40,374.00
126,305.90	2,500.00	264.00	324.00	200.00	339.00	180.00	3,807.00
108,705.37	1,690.56	163.56	464.51	2,674.30	13,912.06		18,904.99
360,071.19	6,650.46	1,477.36	5,173.71	1,589.65	3,586.71	10,694.38	29,172.27
42,615.65	958.28	504.42	1,592.83	2,446.15	1,577.90	1,034.10	8,113.68
104,667.08	1,479.18	113.94	412.39	1,733.98	5,511.47	346.60	9,597.56
82,753.88		167.00		300.00	6,215.00		6,682.00
			743.49			418.53	1,162.02
2 31,313.69	1,086.59	260.90	56.48	294.01	26.03		1,724.01
36,664.88	1,250.00	600.00	160.00	160.00	216.00	150.00	2,536.00
46,871.03	1,795.88	183.63	771.25	1,486.59	450.49		4,687.84
56,605.77	3,826.25	54.95	167.38	1,366.27	2,444.42	120.23	7,979.50
59,952.91	762.00	384.00	356.87	1,414.27	3,545.00	587.08	7,049.22
191,853.33	118,614.76	11,762.40	10,690.75	24,270.20	32,387.33	8,517.97	206,243.41
47,245.02	892.47	96.99	76.92	805.19	200.00	1,494.75	3,506.32
35,695.71		52.84	73.06	278.47	13.50	26.09	443.96
60,777.65	774.72	186.18	92.98	646.74	955.00		2,655.62
99,272.32	4,215.50	59.45	137.09	158.95	600.00	129.11	1,084.00
73,719.55		344.85	625.52	826.57	922.95	598.50	7,533.89
138,562.00	3,652.94	1,200.44	3,236.39	3,292.92	3,545.35	1,625.91	16,553.95
33,603.17	849.00	105.58	1,529.81	1,062.98	1,913.69	81.90	5,542.66
5,334,073.93	499,345.97	42,393.25	87,827.92	99,791.32	230,428.07	59,189.52	1,018,976.05

Station.	Amount of appropriation.	Classified expenditures.								
		Salaries.	Labor.	Publications.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemicals and laboratory supplies.	Seeds, plants and sundry supplies.	Fertilizers.
Alabama.....	\$15,000.00	\$7,450.00	\$2,401.08	\$1,060.84	\$276.25	\$50.23	\$410.46	\$139.92	\$586.84	\$361.89
Arizona.....	15,000.00	7,276.98	5,199.46	1,615.21	717.12	126.91	111.72	214.53	91.91	31.00
Arkansas.....	15,000.00	8,308.25	728.17	778.08	242.66	392.95	106.73	288.82	542.28	.....
California.....	15,000.00	9,793.92	1,503.91	3,285.07	36.31	35.74	146.63	19.09	158.17	.....
Colorado.....	15,000.00	11,081.40	1,175.92	1,175.75	360.36	59.02	63.14	28.40	94.29	.....
Connecticut (State)	7,500.00	.....	220.89	.....	3.36	.....	.....	1.15	6.49	.....
Delaware.....	7,500.00	7,238.09	1,672.00	1,974.73	420.50	56.89	410.79	111.19	723.32	165.00
Florida.....	15,000.00	7,834.60	2,541.35	1,652.37	681.87	46.66	393.98	8.10	156.16	.....
Georgia.....	15,000.00	10,447.63	2,454.77	255.30	196.83	52.83	143.28	211.39	297.97	1.88
Idaho.....	15,000.00	10,723.04	1,312.60	912.94	87.44	50.22	528.19	73.07	283.97	.....
Illinois.....	15,000.00	10,758.33	558.22	558.44	25.97	26.46	6.99	268.83	928.77	114.82
Indiana.....	15,000.00	7,800.00	856.33	1,363.70	44.33	26.46	25.00	285.19	465.09	.....
Iowa.....	15,000.00	9,305.66	3,071.90	21.16	61.18	2.54	42.84	472.56	251.85	.....
Kansas.....	15,000.00	9,851.80	867.21	1,612.55	597.07	42.84	20.47	44.43	353.91	89.37
Kentucky.....	15,000.00	8,951.46	2,657.64	266.61	52.26	4.59	20.47	44.43	536.63	110.00
Louisiana.....	15,000.00	6,957.21	2,722.75	116.07	737.33	201.73	557.13	79.30	12.99	114.00
Maine.....	15,000.00	10,921.34	3,069.80	689.39	66.43	4.87	4.87	165.40	48.94	117.70
Maryland.....	15,000.00	14,241.01	512.45	1,449.11	77.27	91.91	44.70	200.15	325.22	1,028.35
Massachusetts.....	15,000.00	9,476.90	5,000.00	5,000.00	.....	.....	.....	.....	.....	.....
Michigan.....	15,000.00	9,300.00	2,733.38	607.07	227.74	221.04	41.82	456.05	415.04	.....
Minnesota.....	15,000.00	8,170.95	976.99	583.75	782.30	53.15	6.50	350.20	486.05	.....
Mississippi.....	15,000.00	8,228.45	1,165.68	1,912.43	451.85	94.88	23.57	173.89	365.75	27.90
Missouri.....	15,000.00	7,292.79	3,104.28	1,453.80	489.54	80.51	50.47	150.66	295.04	.....
Montana.....	15,000.00	8,277.22	1,944.06	1,422.88	382.74	3.57	53.70	200.34	252.25	14.50
Nebraska.....	15,000.00	10,536.49	1,095.27	83.73	687.99	275.40	626.46	36.99	280.49	74.17
New Hampshire.....	15,000.00	10,340.02	955.29	116.38	389.73	107.12	336.02	456.35	208.01	127.25
New Jersey.....	15,000.00	6,404.42	2,818.39	1,343.22	141.54	204.20	175.41	25.14	85.28	.....
New Mexico.....	15,000.00	1,174.86	134.13	17.76	16.21	.....	.....	.....	.....	.....
New York (State)	13,500.00	6,956.07	4,159.39	60.00	206.83	104.65	19.80	179.80	165.52	.....
New York (Cornell)	15,000.00	7,232.60	2,872.61	230.05	217.61	139.64	209.66	179.23	373.16	784.21
North Carolina.....	15,000.00	14,724.84	4,400	10.62	.....	.....	.....	.....	44.08	.....
North Dakota.....	15,000.00	5,086.05	6,919.70	67.51	69.78	.....	.....	238.79	441.10	.....
Oklahoma.....	15,000.00	7,723.31	1,881.09	110.25	384.50	53.02	14.17	362.04	768.59	168.22
Oregon.....	15,000.00	8,941.51	1,481.31	689.28	592.12	89.82	51.52	141.32	153.97	.....
Pennsylvania.....	15,000.00	9,820.00	2,500.00	1,278.25	296.40	66.80	14.20	27.12	61.58	519.20

Expenditures from United States appropriation received under the act of Mar. 2, 1887 (Hatch Act), for the year ended June 30, 1916—Continued.

Classified expenditures—Continued.										
Station.	Feeding stunts.	Library.	Tools im- plements, and ma- chinery.	Furniture and fixtures.	Scientific apparatus and specimens.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.
Nevada.....	\$413.79	\$124.84	\$408.72	\$723.51	\$420.45	\$203.17	\$971.80	\$22.50	\$601.67	.....
New Hampshire.....	142.97	127.28	99.94	39.65	16.23	30.00	298.18	2.00	36.65	.....
New Jersey.....	1,139.09	101.09	146.21	322.23	239.10	412.00	238.57	870.01	254.50	373.79
New Mexico.....	.....	31.52	586.11	101.31	21.38	.....	17.00	7.20	9.30	\$36.99
New York (State).....	.....	.....	.....	.....	.....	.....	1,005.45	1,005.45	93.06	\$13.03
New York (Cornell).....	768.79	25.68	505.41	16.93	1.51	.....	389.56	153.89	20.00	750.00
North Carolina.....	.....	88.08	503.49	137.27	.....	.....	106.73	17.35	25.40	358.47
Ohio.....	.....	12.70	278.88	1,166.50	316.62	18.30	313.26	22.33	748.98	.....
Oklahoma.....	139.55	167.62	1,105.12	389.98	435.97	12.00	784.44	33.90	25.35	.....
Oregon.....	1,663.68	5.90	68.25	148.13	26.00	3.00	.....	.....	.....	.....
Pennsylvania.....	286.85	58.61	70.00	.....	.....	.....	.....	.....	.....	.....
Rhode Island.....	524.55	337.17	237.10	12.22	11.80	.....	249.20	20.00	135.99	.....
South Carolina.....	871.17	112.64	297.61	25.75	10.85	.....	715.70	20.00	46.94	.....
South Dakota.....	221.25	36.27	480.92	.....	.....	.....	1,207.30	119.04	20.00	48.29
Tennessee.....	609.37	184.02	318.49	376.31	16.83	.....	20.33	20.00	.....	.....
Texas.....	98.14	48.17	196.40	288.54	507.06	.....	246.15	20.00	461.36	.....
Utah.....	1,222.16	36.28	424.87	610.95	14.91	160.00	394.30	20.00	654.93	.....
Vermont.....	877.87	38.60	20.78	21.23	.....	458.10	488.43	20.00	289.87	.....
Virginia.....	371.80	241.64	211.91	23.57	5.03	120.00	283.30	40.00	497.36	.....
Washington.....	.....	226.51	68.31	401.97	207.00	.....	1,365.40	20.00	.....	.....
West Virginia.....	57.25	5.00	494.23	.....	.....	.....	822.29	.....	.....	.....
Wisconsin.....	2,829.50	62.37	.....	255.02	166.30	.....	193.15	.....	.....	.....
Wyoming.....	1,578.80	22.92	319.31	32.50	8.00	400.00	.....	.....	.....	.....
Total.....	27,603.76	5,664.88	11,227.81	7,731.98	4,557.54	\$8,787.93	15,999.28	982.42	9,467.80	1,256.00

STATISTICS OF THE EXPERIMENT STATIONS. 305

Station.	Amount of appropriation.	Salaries.	Labor.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemicals and laboratory supplies.	Seeds, plants, and sundry supplies.	Fertilizers.
Classified expenditures.									
Alabama.....	\$15,000.00	\$10,096.80	\$1,771.52	\$162.98	\$259.04	\$33.14	\$489.60	\$230.39	\$104.14
Arizona.....	15,000.00	10,647.39	1,281.05	57.53	111.00	30.75	254.18	146.38	185.38
Arkansas.....	15,000.00	9,147.28	1,470.18	31.77	132.36	231.60	581.91	1,065.02	.....
California.....	15,000.00	11,279.04	1,680.60	27.43	34.39	.....	467.15	232.78	.....
Colorado.....	15,000.00	7,500.00	315.57	16.57	42.24	128.38	58.83	129.13	19.00
Connecticut (State).....	15,000.00	5,759.84	189.00	56.38	76.32	41.95	287.36	140.79	42.40
Connecticut (Stores).....	6,024.84	1,065.11	.....	.....	11.25	.....	2.00	365.46	.....
Delaware.....	7,500.00	2,297.23	1.00	.....	36.96	169.45	827.15	377.80	40.00
Florida.....	15,000.00	8,869.38	1,772.84	747.21	16.47	140.13	112.70	651.73	55.51
Georgia.....	15,000.00	10,211.36	1,515.55	35.46	66.15	669.98	265.19	.....	.....
Idaho.....	15,000.00	8,581.15	2,133.20	54.14	319.79	117.96	459.96	325.42	.....
Illinois.....	15,000.00	12,346.66	997.54	37.85	18.2	.....	201.77	130.24	.....
Indiana.....	15,000.00	11,339.72	943.25	97.07	*64	.....	286.78	51.56	.....
Iowa.....	15,000.00	9,328.50	819.28	1.25	74	206.57	1,010.19	758.75	431.38
Kansas.....	15,000.00	8,888.01	2,066.39	1.64	89.15	117.30	553.92	173.32	7.60
Kentucky.....	15,000.00	12,541.66	605.30	15.70	23.56	147.31	165.68	196.70	10.00
Louisiana.....	15,000.00	12,718.35	7,031.07	49.30	284.44	123.59	242.21	153.76	.....
Maine.....	15,000.00	11,586.14	30.23	107.46	76.08	181.79	1,033.58	441.19	.....
Maryland.....	15,000.00	8,724.26	808.62	64.91	74.78	.....	.....	.....	.....
Massachusetts.....	15,000.00	10,093.80	2,064.38	5.69	*69	.....	633.47	91.40	.....
Michigan.....	15,000.00	14,550.00	4,600.00	.....	.....	.....	12.57	31.20	.....
Minnesota.....	15,000.00	9,724.96	3,609.05	48.72	1.55	6.00	365.41	270.39	117.80
Missouri.....	15,000.00	7,084.35	3,731.85	26.88	118.23	7.54	425.81	74.33	.....
Montana.....	15,000.00	13,142.68	443.06	36.41	36.69	51.37	344.55	.....	.....
Nebraska.....	15,000.00	11,428.58	1,118.80	16.85	39.23	.....	940.55	271.94	.....
Nevada.....	15,000.00	12,059.72	204.80	30.40	6.00	288.11	299.14	146.67	201.75
New Hampshire.....	15,000.00	9,574.12	3,076.75	*29	16.73	.....	871.17	158.19	12.82
New Jersey.....	15,000.00	11,313.32	1,513.90	8.18	23.31	339.60	769.68	281.76	11.95
New Mexico.....	15,000.00	8,461.98	2,259.64	79.54	223.77	604.26	.....	.....	.....
New York (State).....	15,000.00	1,500.00	1,275.04	.....	.....	.....	440.09	159.15	.....
New York (Cornell).....	15,000.00	9,060.00	3,426.28	73.90	3.55	40.25	173.48	184.29	132.27
North Carolina.....	15,000.00	12,166.98	1,121.60	82.33	.....	5.00	973.97	90.66	3.50
North Dakota.....	15,000.00	11,335.03	210.93	8.00	.....	.....	1,983.26	491.10	.....
Ohio.....	15,000.00	3,240.13	4,336.38	1.72	16.42	22.96	99.53	344.62	143.25
Oklahoma.....	15,000.00	7,049.27	1,167.45	592.67	3.35	75.79	134.42	664.63	110.55
Oregon.....	15,000.00	12,775.00	1,602.97	3.54	93.25	100.00	436.02	393.61	990.79
Pennsylvania.....	15,000.00	10,352.82	.....	.....	.....	.....	.....	.....	.....

Expenditures from United States appropriation received under the act of Mar. 16, 1906 (Adams Act), for the year ended June 30, 1916—Continued.

Station.	Amount of appropriation.	Classified expenditures—Continued.						
		Salaries.	Labor.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemicals and laboratory supplies.	Seeds, plants, and sundry supplies.
Rhode Island.....	\$15,000.00	\$7,572.06	\$3,852.57	\$74.22	\$66.42	\$501.29	\$259.18	\$396.56
South Carolina.....	15,000.00	7,346.31	4,172.37	100.75	2.20	72.07	814.00	306.04
South Dakota.....	10,610.86	2,400.31	1,31.32	131.32	99.74	572.64	498.54	275.81
Tennessee.....	10,764.99	1,241.19	13.27	163.44	110.77	648.39	106.36	15.80
Texas.....	9,467.32	1,521.51	48.06	199.10	96.09	884.26	304.61	10.00
Utah.....	15,000.00	9,620.90	2,776.81	24.92	3.84	243.80	835.22	148.70
Vermont.....	15,050.00	9,709.39	2,562.16	48.81	14.21	243.20	343.22	202.20
Virginia.....	10,542.15	7,80	77.75	192.41	46.22	378.43	134.19	1.88
Washington.....	15,000.00	8,799.80	3,070.07	41.99	134.35	297.10	233.94	205.86
West Virginia.....	13,000.00	11,140.80	652.50	22.76	2.54	454.92	318.36	12.85
Wisconsin.....	15,000.00	8,900.00	2,353.83	71.47	79.97	86.86	168.25	46.51
Wyoming.....	15,000.00	9,297.64	670.75	.....	91.00	51.24	847.16	.....
Total.....	720,000.00	497,432.31	80,025.07	1,732.94	3,506.50	6,654.40	25,561.42	12,605.07
								2,609.90

¹ Including balance from previous year: \$0.25.

Station.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Scientific apparatus and specimens.	Furniture and fixtures.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.
Alabama.....	\$372.20	\$62.24	\$55.09	\$84.15	\$219.19	\$183.80	\$238.02	.....	\$327.70	.....
Arizona.....	185.40	1.35	141.12	5.00	985.36	43	760.41	.....	344.16	\$4.39
Arkansas.....	172.86	32.90	285.43	126.05	371.55	246.46	871.23	.....	26.70	.....
Colorado.....	62.24	14.79	28.56	175.00	74.31	75.13	283.46	.....	104.00	.....
Connecticut (State).....	153.82	9.09	200.49	49.85	373.23	13.44	172.60	.....	.....	.....
Connecticut (Storrs).....	48.35	70.25	64.70	.....	.....	5.30	15.09	407.57	137.95	975.00
Delaware.....	11.25	.....	.....	.....	218.21	30.00	77.93	.....	58.68	.....
Florida.....	435.03	128.99	48.19	99.66	87.17	422.00	78.36	20.00	441.38	.....
Georgia.....	349.58	146.87	19.82	137.02	170.25	.....	.....	.....	.....	.....

	Total	43.92
Idaho	39.00	47.27
Illinois	633.88	263.89
Indiana	1,177.30	35.14
Iowa	1,943.66	117.65
Kansas	329.55	89.09
Kentucky	121.35	121.42
Louisiana	1,619.31	44.84
Maine	334.00	44.87
Maryland	249.76	178.03
Michigan	27.67	54.62
Tennessee	22.09	17.47
Pennsylvania	2,616.35	3.15
Montana	44.84	91.24
Nebraska	202.99	73.19
Nevada	408.76	169.02
New Hampshire	542.53	32.55
New Jersey	360.00	58.35
New Mexico	495.99	1.15
New York (State)	30.39	63.12
New York (Cornell)	25.51	12.50
North Carolina	615.04	107.72
North Dakota	313.73	413.72
Ohio	2,014.21	312.48
Oklahoma	226.25	26.18
Oregon	1,076.86	13.61
Pennsylvania	490.09	40.16
Rhode Island	5.76	327.64
South Carolina	17.34	48.66
South Dakota	149.55	320.13
Tennessee	13.54	482.10
Texas	52.30	22.77
Utah	1,440.09	14.24
Vermont	728.80	52.88
Virginia	508.35	162.64
Washington	95.21	13.48
West Virginia	2,338.43	81.27
Wisconsin	1,232.51	161.38
Wyoming	25,189.07	2,606.66
	8,503.14	4,848.56
	19,333.90	6,089.28
	11,636.44	1,152.31
	9,871.17	1,641.96

Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved Mar. 2, 1887, and Mar. 16, 1906.

State or Territory.	Hatch Act.		Adams Act.	
	1888-1915	1916	1906-1915	1916
Alabama.....	\$419,199.34	\$15,000.00	\$116,619.89	\$15,000.00
Arizona.....	384,803.15	15,000.00	120,000.00	15,000.00
Arkansas.....	418,139.12	15,000.00	119,360.67	15,000.00
California.....	420,000.00	15,000.00	119,926.84	15,000.00
Colorado.....	419,718.82	15,000.00	118,638.93	15,000.00
Connecticut.....	420,000.00	15,000.00	120,000.00	15,000.00
Dakota Territory.....	56,250.00			
Delaware.....	419,382.87	15,000.00	116,450.12	15,000.00
Florida.....	419,966.06	15,000.00	119,996.06	15,000.00
Georgia.....	419,981.55	15,000.00	116,360.67	15,000.00
Idaho.....	344,824.13	15,000.00	115,842.22	15,000.00
Illinois.....	419,564.95	15,000.00	119,851.62	15,000.00
Indiana.....	419,901.19	15,000.00	115,000.00	15,000.00
Iowa.....	420,000.00	15,000.00	120,000.00	15,000.00
Kansas.....	419,995.00	15,000.00	120,000.00	15,000.00
Kentucky.....	419,996.57	15,000.00	120,000.00	15,000.00
Louisiana.....	420,000.00	15,000.00	120,000.00	15,000.00
Maine.....	419,999.62	15,000.00	120,000.00	15,000.00
Maryland.....	419,967.40	15,000.00	119,763.99	15,000.00
Massachusetts.....	419,617.70	15,000.00	120,000.00	15,000.00
Michigan.....	419,676.10	15,000.00	116,341.20	15,000.00
Minnesota.....	420,000.00	15,000.00	119,315.74	15,000.00
Mississippi.....	420,000.00	15,000.00	120,000.00	15,000.00
Missouri.....	415,097.24	15,000.00	120,000.00	15,000.00
Montana.....	330,000.00	15,000.00	117,417.04	15,000.00
Nebraska.....	419,932.16	15,000.00	120,000.00	15,000.00
Nevada.....	419,214.32	15,000.00	118,180.28	15,000.00
New Hampshire.....	420,000.00	15,000.00	120,000.00	15,000.00
New Jersey.....	419,949.97	15,000.00	119,558.78	15,000.00
New Mexico.....	384,509.05	15,000.00	120,000.00	15,000.00
New York.....	419,559.82	15,000.00	119,880.77	15,000.00
North Carolina.....	420,000.00	15,000.00	120,000.00	15,000.00
North Dakota.....	361,778.34	15,000.00	120,000.00	15,000.00
Ohio.....	420,000.00	15,000.00	118,514.02	15,000.00
Oklahoma.....	344,568.96	15,000.00	101,360.56	15,000.00
Oregon.....	405,156.64	15,000.00	115,000.00	15,000.00
Pennsylvania.....	419,967.43	15,000.00	119,995.41	15,000.00
Rhode Island.....	420,000.00	15,000.00	117,464.20	15,000.00
South Carolina.....	419,542.15	15,000.00	118,460.12	15,000.00
South Dakota.....	363,250.00	15,000.00	115,000.00	15,000.00
Tennessee.....	420,000.00	15,000.00	120,000.00	15,000.00
Texas.....	420,000.00	15,000.00	117,592.26	15,000.00
Utah.....	285,000.00	15,000.00	119,821.94	15,000.00
Vermont.....	420,000.00	15,000.00	120,000.00	15,000.00
Virginia.....	417,824.12	15,000.00	119,949.26	14,999.75
Washington.....	357,102.65	15,000.00	116,050.11	15,000.00
West Virginia.....	419,968.71	15,000.00	117,859.12	15,000.00
Wisconsin.....	420,000.00	15,000.00	120,000.00	15,000.00
Wyoming.....	405,000.00	15,000.00	120,000.00	15,000.00
Total.....	9,548,700.13	720,000.00	5,686,171.15	719,999.75

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NOTE.—The abbreviations "Ala.College," "Conn.State," "Mass.," "P.R.," etc., after entries refer to the work of the respective experiment stations, and the words "bulletin," "circular," "memoir," etc., before such abbreviations refer to publications of the respective experiment stations mentioned by title in the text.

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